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Biological Investigations of Noxious Coelenterates and Ctenophores in Coastal North Carolina

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Abstract

A year long study was made of the coastal waters of North Carolina in 1972 to resolve the questions of what coelenterates and ctenophores occur therein and are they a problem to man. Eight species of jellyfishes, Chrysaora quinquecirrha, Cyanea capillata, Rhopilema verrilli, Aurelia aurita, Stomolophus meleagris, Nemopsis bachei, Physalia sp. and Blackfordia manhattensis and two ctenophores, Mnemiopsis leidyi and Beroe ovata were encountered. Each had a seasonal preference as to occurrence, water temperature, salinity, and depth distribution. Chrysaora quinquecirrha and Mnemiopsis leidyi population abundances were influenced by salinity, water temperature, and their own interaction. Albemarle Sound yielded no jellyfishes and few ctenophores while the sounds south of Pamlico Sound possessed no or few jellyfishes and sparse populations of ctenophores. Highest incidences of Chrysaora polyps and cysts occurred in Pamlico Sound, especially that southern shore arc area between Cedar Island and Swanquarter Bay. Several recommendations for future research and action are included.

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Biological Investigations of Noxious Coelenterates and Ctenophores in Coastal North Carolina

The Jellyfish act (PL 89-720) was passed to "provide assistance to the states in controlling and eliminating jellyfish and other such pests in such waters." Before control or elimination of these, often referred to as noxious coelenterates, can be attempted one must accumulate considerable information on the species involved. Most laymen, fishermen, and scientists simply and grudgingly accepted their presence, on occasion, until they interfered with their use of the estuarine and marine waters of North Carolina, whether for boating, sport of commercial fishing, swimming, livelihood, or esthetics. Such was the state of the art in North Carolina until late 1971.

In late 1971 a project was devised to provide answers to the questions of what species of jellyfishes and ctenophores inhabit North Carolinian waters, at what seasons, at what depths, in what abundance, what were their biological life histories and needs, what associations of species and environment triggered or permitted their presence, and more importantly how did all these affect man and his utilization of the area.

Study Area

The coastal estuarine and marine waters of North Carolina were arbitrarily divided into five sampling areas (Fig. 1). These had some contiguity in relation to location, general ecology, salinity, etc.

Area 1 - Albemarle region: included Albemarle Sound, Croatan Sound, and tributaries south to Oregon Inlet.

Area 2 - Pamlico region: included Pamlico Sound, Pamlico and Neuse Rivers and tributaries from Oregon Inlet north to Core Sound.

Area 3 - Core-Bogue region: included Core and Bogue Sounds and tributaries south to Bogue Inlet.

Area 4 - New River region: included New River and all estuarine areas from Bogue Inlet south to the Cape Fear River.

Area 5 - Cape Fear region: included Cape Fear River and estuarine areas south to the South Carolina line.

Past Geologic History: Geologic processes have moved the North Carolina coast line back and forth, from far inland, to far at sea, or to the present conditions as the Atlantic Ocean waters rose and fell, as a function of the natural tectonic activities of the planet Earth (Flint, 1947). These eustatic changes and their estimates are numerated by Curray (1965) and Stearns (1969).

With sea level lowering, the existent drainages must have elongated, ramified, or anastomosed into the mosaic recorded off Cape Hatteras (Newton, Pilkey, and Blanton, 1971). Darton (1894), Shattuck (1906), and Lachner and

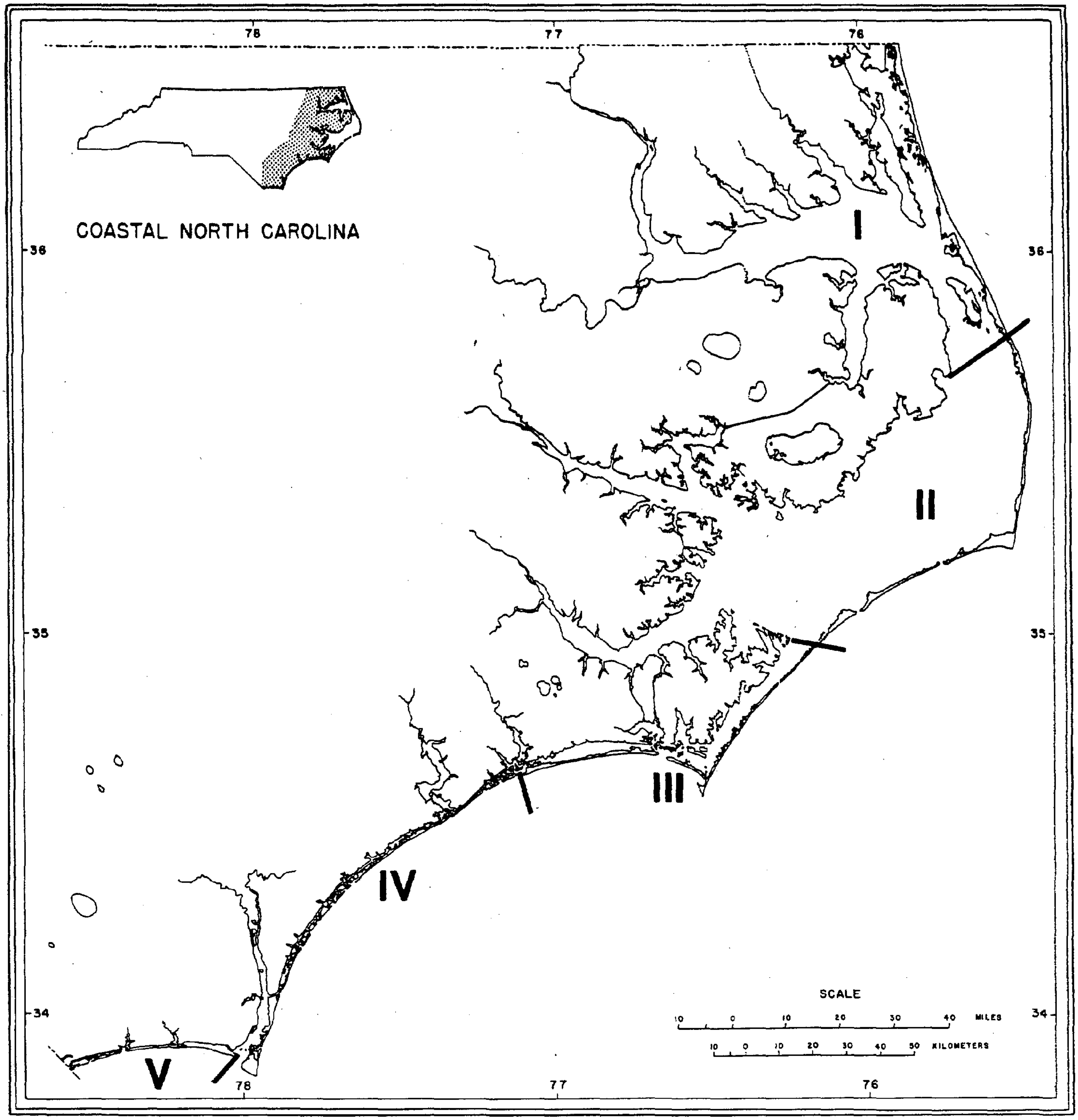


Figure 1. A map of coastal North Carolina illustrating the five geographic areas studied in 1972.

Jenkins (1971) noted the interdrainage connections for central Atlantic slope streams, which drained levels now part of the continental shelf: the greater *Susquehanna River*, the greater Roanoke River, and probably the greater Pamlico River. The increased runoff that must have existed then or following deglaciation (Schumann, 1965; Whitehead, 1965), along with the colder prevailing world temperatures, must have favored freshwater conditions, or restricted the marine fauna to clearer, less turbid, or sediment laden areas, at least north of Wilmington. While the above favorable conditions permitted much stream faunal interchange, especially in the Chesapeake Bay area (Jenkins, Lachner, and Schwartz, 1972), it did not affect the biogeographic boundary between the Cape Fear and Neuse River faunas (Cole, 1967).

Later warming of the world and water temperatures (Kincer, 1933; Richards, 1936, 1950; Richards and Judson, 1965) most likely influenced the shifts in marine and freshwater faunas to that we encounter today. The rising sea levels shifted the coast line inland (Oaks and Coch, 1963) and permitted a coastal and shelf fauna to predominate. This is substantiated by the fossil Pamlico formation record which revealed that many marine forms occupied the area during this oscillation (Richards, 1936, 1950; Richards and Judson, 1965).

Physical and Chemical Features of Area: Starting at the high tide mark we find most estuaries possess a mud or silty-mud substrate. These persist throughout most river estuaries and the great sounds north of Cape Lookout (Pickett and Ingram, 1969). At the eastern limits of the sounds, the Outer Banks, the bottom composition is sandier, especially in the vicinity of inlets (Ingram, 1968; Pickett and Ingram, 1969). South of Pamlico Sound, Bogue Sound, and most of the narrow short sounds south of Cape Lookout are sandier in texture, especially on their southern shores (Brett, 1963; Kruczynski, 1971); the adjoining estuaries, however, have beds of mud often overlain with silt. Manheim, Mead, and Bond (1970) commented that considerable amounts of suspended matter escaping from the inshore sounds also tends to move longshoreward rather than seaward.

Temperature and Salinity Profiles: The usual progressions exist from low salinities inland to near sea water conditions along the outer and coastal banks (Williams and Deubler, 1968; Williams, Murdoch, and Thomas, 1968; and Williams, Posner, Woods, and Deubler, 1967).

Circulation and Current Patterns: Circulation patterns within the coastal sounds are poorly known (Brett, 1963; Roelofs and Bumpus, 1963) while surface or shelf water currents are better known (Bumpus and Lanzier, 1965).

Invertebrate fauna: While the above tectonic shifts undoubtedly occurred and various faunas must have developed and been subjected to the equally harsh changes in the environment, from freshwater to oceanic water to lower estuarine conditions, oyster beds or rocks did develop in all coastal areas (Chestnut, 1955; Grave, 1904; Winslow, 1889). Other benthic organisms also found, for proliferation and existence, their preferred habitat and ecological requirements met by the inland coastal areas of North Carolina (Wells, 1961; Crump, 1971; Bird, 1970; Porter, 1969; and Williams and Porter, 1971). Whether the then less dammed up streams draining North Carolina brought more fresh water into the coastal sounds and estuaries to proliferate or control these faunas is not well documented. Neither are there good observations of the presence of absence, numbers, species of coelenterates and ctenophores during past to present times.

Likewise, man is only now becoming aware of the effects of his activities of draining, channelization, and pollution as factors which indirectly may be aiding the proliferation of coelenterates and ctenophores. Man did, however, in his greediness, overfish the natural oyster and hard substrate bottoms of the coastal areas (Chestnut, 1951; Coker, 1907). Whether this action had a direct influence on the coelenterate-ctenophore problem is unknown.

Methods

Sampling vessels: Two methods were employed to sample the 84 stations established throughout coastal North Carolina waters (Fig. 2). The 14.3 m R/V Machapunga, which is equipped for long distance overnight trips, with winch, booms, etc., was used monthly throughout the area north of Morehead City. South of Morehead City quarterly cruises were made with the Machapunga in February, May, August, and November. During all other months, those stations south of Morehead City and in Core Sound were made using a 5.5 m skiff outfitted with an outboard motor. In areas from Morehead City north, such as the Newport River and Pamlico Sound tributaries, where depths were too shallow for the 1.7 m draft of the Machapunga, skiffs were the additional means of sampling, on a monthly schedule.

Collecting gear: Trawls: Semi-balloon 13.7 or 12.2 m flat shrimp trawls were used aboard the Machapunga. These nylon nets, 38 mm body, 19 mm bag, had tickler chains preceeding them. Otter board doors were 0.7 x 1.5 m towed by two wire cables, one to each door. Semi-balloon trynet trawls (5.5 or 6.1 m) were towed from the skiff. These had 32 mm body, 19 mm bag with a 6.4 mm knotless liner. All trawls were towed at a cable length to depth ratio of 3:1.

Dredges: Standard hand oyster dredges 0.6 m wide, with the regular bag lined with 6.4 mm knotless nylon, were used to sample marl and oyster beds for live polyp and cyst bearing oysters or marl. These were towed at a 3:1 scope ratio from either type of vessel.

Plankton nets: Meter and half meter nylon plankton nets were bridled and towed at or just under the surface from the Machapunga or skiffs. Material was of Stern and Stern fabric pattern A5274 with resin finish. This permitted the best straining to retention ratio known (Dovel, 1964). A screen (Heinle, 1965) or other methods (Burrell and Van Engel, 1970) were not used to exclude the various jellyfishes and ctenophores.

Sampling time: Twenty minute tows were made for the stations along the transect from Garbacon light to Ocracoke, North Carolina, until July; thereafter, the towing time was reduced to 10 minutes. At all other stations, regardless of vessel, tows were of 10 minute duration.

Shell bags: Wire bags of hexagonal design 25.4 mm chicken wire, 30.5 cm on a side were filled with 30 oysters shells and set in Turnagain Bay, South River, and the Thorofare in April and May 1972 by attaching them to pilings. Natural inclement weather, storms, and uncontrollable events precluded their successful use.

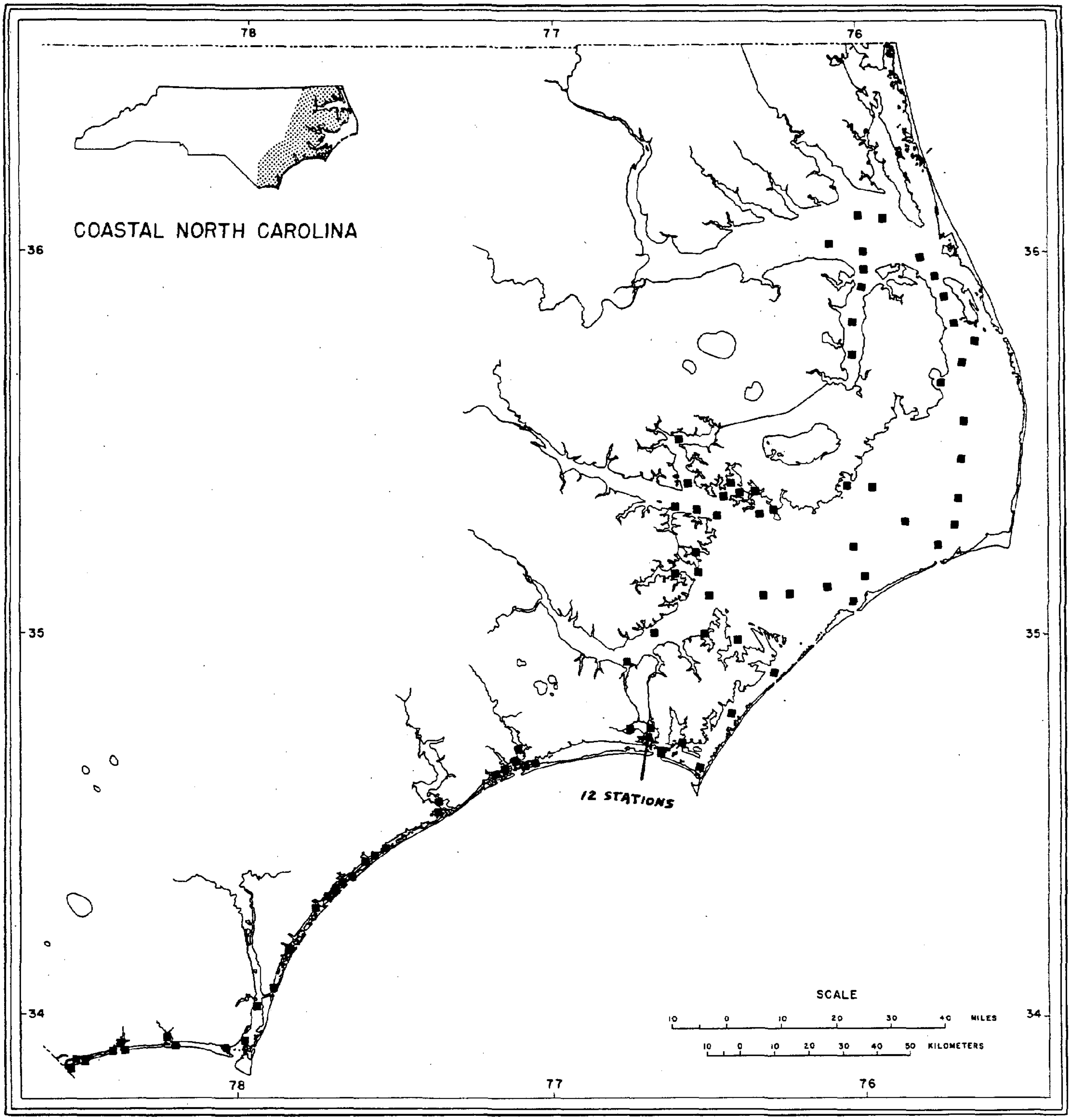


Figure 2. A map of coastal North Carolina illustrating the 84 sample sites.

Environmental Parameters:

a) Temperature: Surface and bottom temperatures were determined with standard mercury or alcohol thermometers. These are reviewed separately by Schwartz and Chestnut (1973).

b) Water samples: Water samples were obtained by draw bucket (surface) or at all other depths employing one or 3.1 liter Kemmerer water samplers.

c) Oxygen: Oxygen samples were collected by placing water collected with Kemmerer samplers into 100 or 250 ml bottles. A standard modified winkler titration method was then performed to determine O_2 present (Strickland and Parsons, 1968).

d) Salinity: Salinity was determined by using refractometers which read directly to the nearest part per thousand. These are reviewed separately by Schwartz and Chestnut (1973).

e) Hydroclimatographs were constructed for 18 arbitrarily (Figs. 3-5) chosen stations (of the 84 total) to illustrate the stable or unstable environmental conditions often encountered in the five sample areas in 1972. These note the relationships between temperature (°C) and salinity (ppt).

Sampling stations: A maximum of 84 stations (Tables 1, 2) were established throughout the coastal area (Fig. 2). Transects usually extended from Adams Creek to Ocracoke to Wysocking Bay to Hatteras Inlet to Stumpy Point to Oregon Inlet to Croatan Sound to near Currituck Sound toward Pasquotank River to the firing platform in Albemarle Sound to and down Alligator River through the inland waterway down Pungo River through Rose Bay and Swanquarter Bay to Pamlico Light to the inland waterway to Hobucken to Jones Bay to Bay River to Neuse River and return to Morehead City.

Core Sound and adjacent areas of Turnagain Bay, South River, etc., were sampled by entering the Thorofare south of Cedar Island then proceeding south to Barden and Beaufort inlets.

To the south, simple progression up the inland waterway from the North Carolina-South Carolina state line to Morehead City traversed all the designated stations.

The nearest available waterways were utilized as access, in all areas, where oyster beds were sampled in nearby shallow waters.

Bridge stations: Six bridges on the Neuse River, Trent River, Emerald Isle Causeway, Atlantic Beach Causeway, Morehead-Beaufort Causeway, and North River were used from which meter plankton nets were streamed monthly for five minutes to note additional ctenophore-jellyfish occurrences and abundances.

Additional daily bridge observations were possible by the cooperation of bridge tenders stationed thereon and who submitted data on presupplied data forms (see later discussion).

Figure 3. Hydroclimatographs for six arbitrary sample sites in Areas 1 and 2.

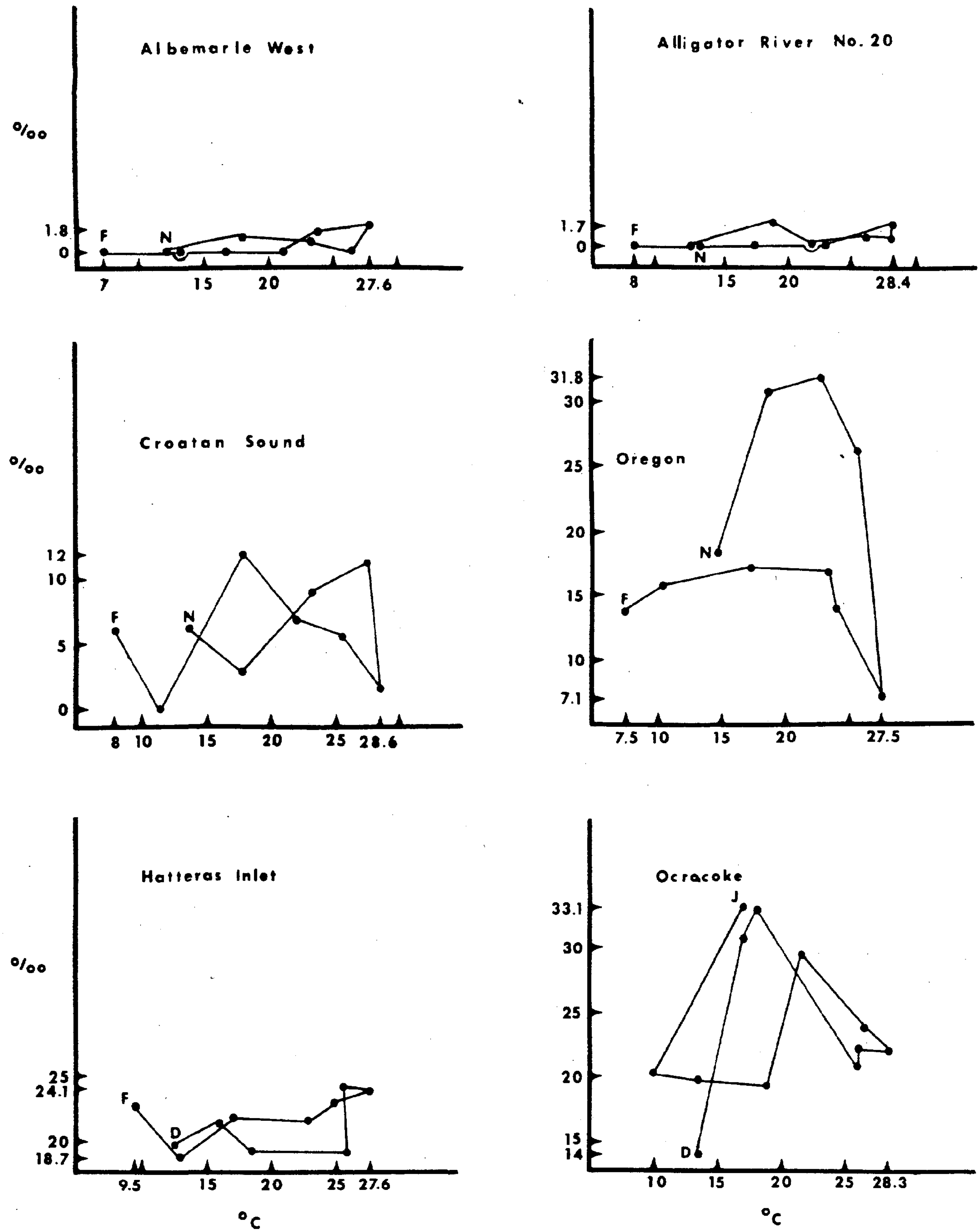


Figure 4. Hydroclimatographs for six arbitrary sample sites in Areas 2 and 3.

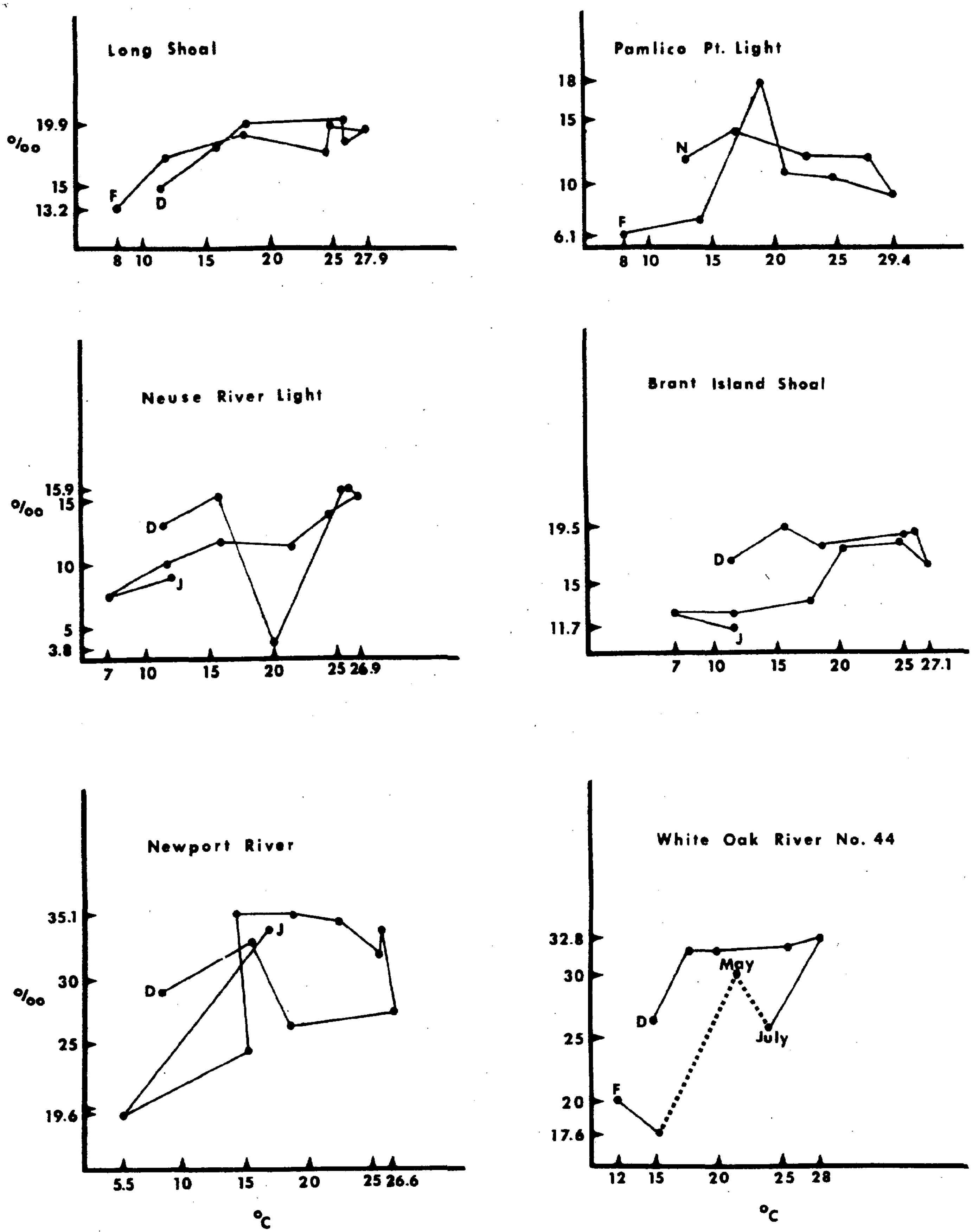


Figure 5. Hydroclimatographs for six arbitrary sample sites in Areas 4 and 5.

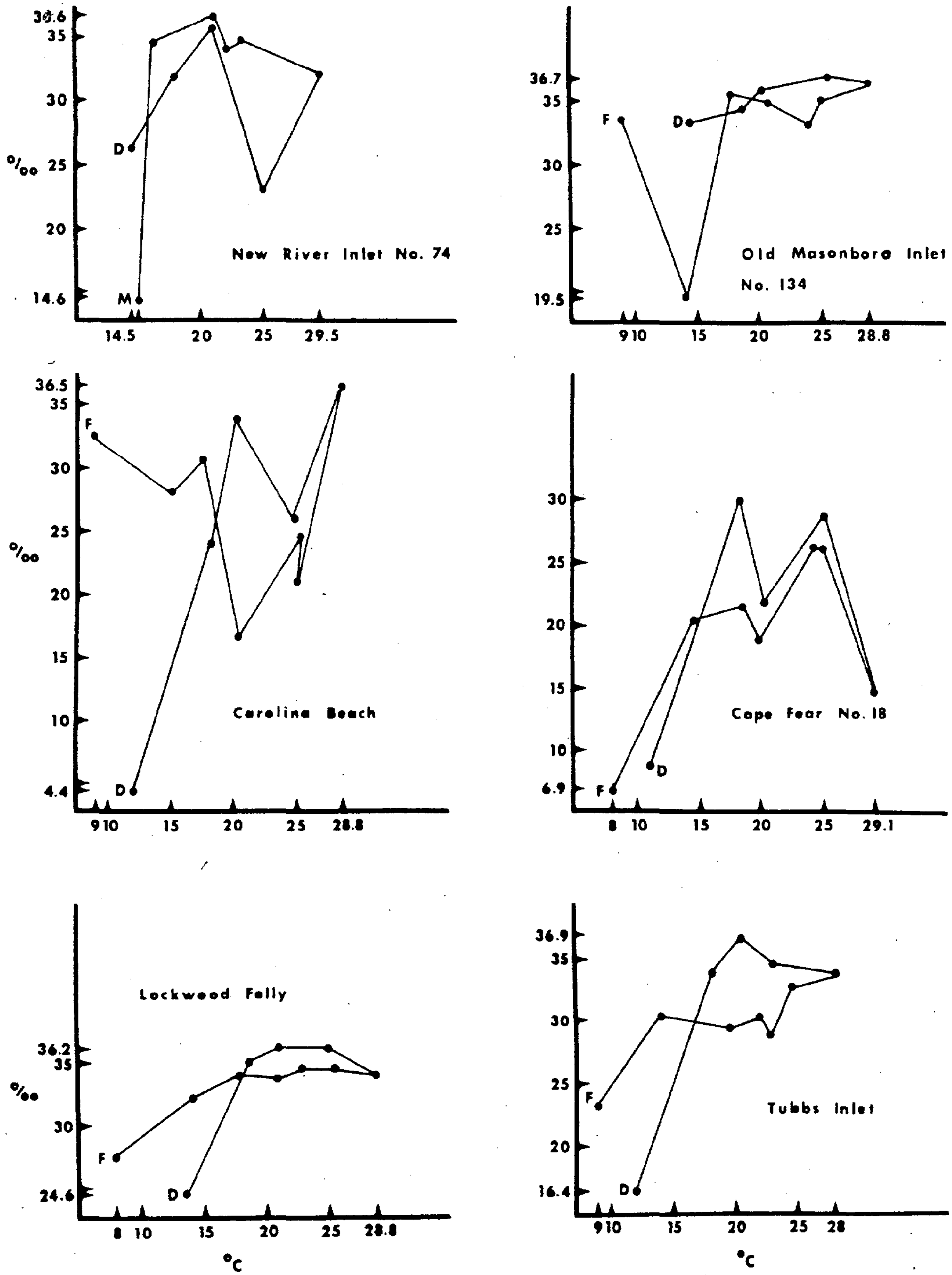


Table 1. Number, type, and station designation for 14 samples in Area I, 41 in Area II, 37 in Area III, 14 in Area IV, and 11 in Area V. Exact longitude and latitude for each station can be found in Schwartz and Chestnut 1973 (Table 83).

AREA I

1.	Stumpy Point East	9.	Albemarle West
2.	Oregon Inlet	10.	Albemarle South
3.	Croatan South	11.	Alligator Entrance
4.	Croatan	12.	Alligator Eight
5.	Croatan North	13.	Alligator Twenty
6.	Albemarle East	14.	Alligator Twenty-eight
7.	Albemarle North	0	Dredge Stations
8.	Albemarle Northwest	14	Trawl & Plankton

AREA II

1.	Garbacon Shoal	23.	Rose Bay
2.	Gum Thicket Shoal - Marker R"6"	24.	Ranger Point (dredge)
3.	Neuse River Entrance Light	25.	Swan Point (dredge)
4.	Brant Island Shoal West	26.	Swanquarter Narrows (dredge)
5.	Brant Island Shoal	27.	Swanquarter Bay
6.	Brant Island Shoal East	28.	Swanquarter Harbor (dredge)
7.	Royal Shoal	29.	Pamlico Point
8.	Big Foot Slough Channel	30.	Oyster Creek
9.	Ocracoke 9	31.	Goose Creek
10.	Teach's Hole Channel	32.	Jones Bay - Maiden Point
11.	Bluff Shoals	33.	Bay River - Bonner Bay (dredge)
12.	Wysocking Bay (dredge)	34.	Bay River
13.	Wysocking Bay - Gull Shoal R"4"	35.	Bay River - Bay Point
14.	Southeast of Gull Shoal	36.	Turnagain Bay (dredge)
15.	Hatteras Inlet	37.	Turnagain, Trawl
16.	Hatteras Inlet - Shark Shoal	38.	West Bay (dredge)
17.	Northwest of Clam Shoal	39.	West Bay 6, Trawl
18.	Pamlico Sound - Long Shoal South	40.	Neuse River - New Bern bridge
19.	Pamlico Sound - Long Shoal North	41.	Trent River bridge
20.	Stumpy Point	8	Dredge Stations
21.	Pungo #3	33	Trawl & Plankton
22.	Pungo-Abel Bay		

Table 2. Number, type, and station designation for 14 samples in Area I, 41 in Area II, 37 in Area III, 14 in Area IV, and 11 in Area V. Exact longitude and latitude for each station can be found in Schwartz and Chestnut 1973 (Table 83).

AREA III

1.	Drum Inlet	14.	Newport River - Station #13
2.	Jarrett Bay (Dredge)	15.	Newport River - Station #14
3.	North River (Dredge)	16.	Newport River - Station #15
4.	Newport River - @ railroad bridge	17.	Bogue Inlet Bridge - @ Swansboro-Bogue banks Bridge
5.	Newport River Station #1 & 2	18.	White Oak River - @ Swansboro bridge
6.	Newport River - Station #3	19.	White Oak River - (Dredge)
7.	Newport River - Station #4	20.	White Oak River east (Trawl)
8.	Newport River - Station #6	21.	Borden's Inlet
9.	Newport River - Station #7	22.	Shackleford
10.	Newport River - Station #8	3	Dredge Stations
11.	Newport River - Station #10	17	Plankton
12.	Newport River - Station #11	17	Trawl
13.	Newport River - Station #12		

AREA IV

1.	Jarretts Point (dredge)	9.	Virginia Creek (dredge)
2.	Masonboro Inlet #134	10.	Old Topsail Sound #86 - Sloop Point
3.	Mason Inlet - Howe Point	11.	New River Inlet #74
4.	Pages Creek	12.	New River (dredge)
5.	Mason Channel (dredge)	13.	Bear Inlet - Saunders Creek #55
6.	Futch Creek (dredge)	14.	Bogue Inlet - Queens Creek #49
7.	Green Channel #105	5	Dredge Stations
8.	Howard Channel - New Topsail Inlet	9	Trawl & Plankton

AREA V

1.	Little River Inlet - Bonaparte Creek	7.	Lockwoods Folly (dredge & trawl)
2.	Little River Inlet (dredge)	8.	Elizabeth River #11
3.	Tubbs Inlet	9.	Cape Fear #18
4.	Sauce Pan Creek (dredge)	10.	Cape Fear #174
5.	Shallotte Point (dredge)	4	Dredge Stations
6.	Shallotte Inlet Marker #78 N	7	Trawl & Plankton

Ferry boat observations: Personnel, during routine operations of their respective ferries operating across the Neuse River and Cedar Island to Ocracoke likewise, reported occurrences and abundances of jellyfishes and ctenophores on a daily basis. These were surface observations.

Atlantic Ocean observations: Offshore observations were made possible during cruises aboard the Duke University R/V *Eastward*, by our personnel and other scientists, and the R/V *Machapunga*, by University of North Carolina personnel.

Biological observations:

Ctenophores - The ctenophores *Mnemiopsis leidyi* and *Beroe ovata* were counted at each sample station, if their numbers were small. Where collections produced large gelatinous masses of a respective species their total volume, weight, and sizes (length) were noted.

Jellyfishes - The jellyfishes, *Chrysaora quinquecirrha*, *Cyanea capillata*, *Rhopilema verrilli*, *Stomolophus meleagris*, *Aurelia aurita*, *Physalia* sp., *Nemopsis bachei*, and *Blackfordia manhattensis* were counted, measured (bell diameter), weighed, and their volume (liter) noted for each station.

Other associated organisms: a) fishes were measured (standard length), counted, weighed, and sorted to species, if the sample was small. When samples were large, subsamples were those that filled a standard 11.4 liter pail.

b) crabs were counted, sexed, and released.

c) shrimps: Penaeids, and other shrimps, *Palaemonetes* and *Crangon*, were counted, measured, and released.

d) other associates were simply noted as to number and species.

Observations

Overall observations: Until late 1971 the presence or absence of ctenophores and jellyfishes in North Carolina was simply tolerated with no question of why, when, where, etc., they occurred. This report presents data on many aspects, then unknown, as an attempt to answer the various questions concerning the "noxious" aspects of these invertebrates.

The works of Kramp (1961), Mayer (1910, 1912), Littleford and Truitt (1937), and others resolved much of the systematics of the groups and the task of determining what species we were encountering. The biology of *Chrysaora* was well documented and reviewed by Cargo and Schultz (1966, 1967, 1971). Calder, Cones, and Joseph (1971) brought together the literature dealing with *Aurelia*. Kennedy (1972) reviewed the *Physalia* problem. Cargo (1971) commented on *Rhopilema*. *Stomolophus* has been studied by Phillips, Burke, and Keener (1969) and more recently by Kroeuter in South Carolina.

Sampling effort: During the "biological year" 1972 some 749 plankton, 44 dredge, and 833 otter trawl stations (Tables 1 and 2) were maintained throughout the five sample areas (Fig. 1 and 2, Table 3).

It was not possible to sample all plankton, dredge, or trawl stations, during each month, for a variety of reasons. These were ice, which prevented

Table 3. Sampling Effort irrespective of area, 1972

Month	Plankton	Dredge	Trawl	Interview
J	7	13	12	16
F	69	18	74	10
M	54	0	68	7
A	84	5	79	9
M	72	0	67	1401
J	84	0	80	179
J	53	0	71	36
A	81	0	73	7
S	79	0	79	0
O	70	0	64	4
N	72	0	72	4
D	24*	8	24*	0
Totals	749	44	833	1676

*Trip incomplete due to ship's masts broken.

sampling a few stations in Albemarle Sound, snags tearing gear on the boat, and extreme low water or tides preventing passage through natural waterways.

In the case of plankton samples - the huge volume of organisms, ctenophores, or jellyfishes, on occasion, often ripped the net causing loss of its contents.

Dredge samples were not taken during the May to November period for Cargo and Schultz (1967) have shown that the most likely period for cyst occurrences is during the colder months when water temperatures were below 18°C and salinities were lower (7-20 o/oo).

Problems of torn trawls explain the inability to achieve the full compliment of samples each month even though some 90% of the potential samples were achieved. The January 1972 sample consisted of only the Garbacon-Ocracoke transect rather than sampling the entire five areas. The December sample for Area 1, parts of Area 2 and all of Areas 3-5 was smaller as a snag in Area 1 broke loose the boat stays and bent the masts prohibiting further sampling.

Coelenterates: In general, two species of ctenophores (*Mnemiopsis leidyi* and *Beroe ovata*), eight species of jellyfishes *Chrysaora quinquecirrha*, *Cyanea capillata*, *Rhopilema verrilli*, *Aurelia aurata*, *Stomolophus meleagris*, *Nemopsis bachei*, and *Blackfordia manhattensis* were collected.

BY SEASON: The greatest quantities of coelenterates and ctenophores were encountered during the summer and fall months, primarily May through November (Tables 8-14).

Table 4. Sampling effort by month, type, area, and whether positive (+) or negative observations were obtained for a specific study area. C=ctenophores, J=jellyfishes

January 1972									
		Plankton		Dredge		Trawl		Interviews	
Area	Species	Samples	+ Observations	Samples	+ Observations	Samples	+ Observations	Total	pos.
1								1	
	C								
	J								
2						11	7	1	
	C						6		
	J						2		
3		1	1	7	3	1	1	6	
	C		1		3		1		
	J								
4		3	0	3	0			3	
	C								
	J								
5		3	0	3	1			5	
	C				1				
	J								
Totals		7	1	13	4	12	8	16	

Table 5. Sampling effort by month, type, area, and whether positive (+) or negative observations were obtained for a specific study area.

February 1972									
		Plankton		Dredge		Trawl		Interviews	
Area	Species	Samples	+ Observations	Samples	+ Observations	Samples	+ Observations	Total	Pos.
1		14	3			14	3		
	C		3				3		
	J		3*						
2		8	2	8	5	29	9		
	C		2				7		
	Jm						3**	3	1
	Jcysts				5				
3		29				14			
	C							7	1
	J								
4		11		5		10			
	C								
	J								
5		7		5		7			
	C								
	J								
Totals		69	4	18	5	74	12	10	2

C=ctenophores, J=jellyfishes, *Nemopsis bachei **Cyanea capillata, Jm=mature jellyfish

Table 6. Sampling effort by month, type, area, and whether positive (+) or negative observations were obtained for a specific study area. C=ctenophores, J=jellyfishes

March 1972

		Plankton		Dredge		Trawl		Interviews	
Area	Species	Samples	+ Observations	Samples	+ Observations	Samples	+ Observations	Total	pos.
1		14	1			14			
	C								
	J		1						
2		14	5			31	9		
	C		5				5	4	4
	J						4		
3		9	1			6			
	C		1					3	1
	J								
4		9				9			
	C								
	J								
5		8	1			8			
	C		1						
	J								
Totals		54	8			68	9	7	5

Table 7. Sampling effort by month, type, area, and whether positive (+) or negative observations were obtained for a specific study area. C=ctenophores, J=jellyfishes

		Plankton		Dredge		Trawl		Interviews	
		April 1972							
Area	Species	Samples	+ Observations	Samples	+ Observations	Samples	+ Observations	Total	Pos.
1		14				14	2	1	
	C						2		
	J						1		
2		31	15	5	3	31	16	4	4
	C		17		3		10		1
	J						9		3
3		22	1			17		3	
	C		1						
	J								
4		10	1			10			
	C		1						
	J								
5		7				7		1	1
	C								
	J								1
Totals		84	19	5	3	79	18	9	5
Ctenophores			19				12		1
Jellyfishes							10		4

Table 8. Sampling effort by month, type, area, and whether positive (+) or negative observations were obtained for a specific study area. C=ctenophores, J=jellyfishes

May 1972

Area	Species	Plankton Samples	Plankton + Observations	Dredge Samples	Dredge + Observations	Trawl Samples	Trawl + Observations	Interviews Total	Interviews pos.
1		13	3			14	3	129	10
	C		3				2		
	J						1		
2		32	22			30	12	348	6
	C		22				12		
	J						5		
3		10				6		163	8
	C		1						
	J								
4		10				10	2	63	2
	C						3		
	J								
5		7	1			7		199	1
	C		2						
	J								
Totals		72	29			67	18	902	27

Table 9. Sampling effort by month, type, area, and whether positive (+) or negative observations were obtained for a specific study area. C=ctenophores, J=jellyfishes

June 1972

Area	Species	Plankton Samples	Plankton + Observations	Dredge Samples	Dredge + Observations	Trawl Samples	Trawl + Observations	Interviews Total	Interviews pos.
1		14	3			14	3		
	C		3				1	189	
	J						3		
2		32	17			31	24		
	C		17				9	26	
	J		4				24		
3		21	5			18	1		
	C		5				1	94	8
	J								
4		10	1			10	2		
	C		2				2	46	2
	J								
5		7				7	2		
	C		2				2	1	1
	J								
Totals		84	29			80	32	356	11

Table 10. Sampling effort by month, type, area, and whether positive (+) or negative observations were obtained for a specific study area. C=ctenophores, J=jellyfishes

July 1972									
		Plankton		Dredge		Trawl		Interviews	
Area	Species	Samples	+ Observations	Samples	+ Observations	Samples	+ Observations	Total	pos.
1		2				13	1		
	C							2	2
	J								
2		30	17			29	28		
	C		16				3	1	1
	J		1				26		
3		4	1			12			
	C		1					16	1
	J								
4		10	2			10			
	C		2					12	2
	J								
5		7				7			
	C							5	
	J								
Totals		53	19			71	28	36	6

Table 11. Sampling effort by month, type, area, and whether positive (+) or negative observations were obtained for a specific study area. C=ctenophores, J=jellyfishes

		Plankton		Dredge		Trawl		Interviews	
Area	Species	Samples	+ Observations	Samples	+ Observations	Samples	+ Observations	Total	pos.
				August 1972					
1						14	4		
	C	14							
	J						4		
2		29	9			27	26		
	C		9				7	5	1
	J						26		
3		20				15	1		
	C							1	1
	J						1		
4		11	1			10			
	C		1					1	1
	J								
5		7	1			7	1		
	C		1						
	J						1		
Totals		81	11			73	32	7	3

Table 12. Sampling effort by month, type, and whether positive (+) or negative observations were obtained for a specific study area. *C=ctenophores, J=jellyfishes*

September 1972									
		Plankton		Dredge		Trawl		Interviews	
Area	Species	Samples	+ Observations	Samples	+ Observations	Samples	+ Observations	Total	Pos.
1		14				14	2		
	C								
	J						2		
2		27	10			27	26		
	C		10				14		
	J						24		
3		21	1				1		
	C		1			21			
	J						1		
4		9							
	C					9			
	J								
5		8	2			8	1		
	C		2						
	J								
Totals		79	13			79	30		

Table 13. Sampling effort by month, type, area, and whether positive (+) or negative observations were obtained for a specific study area. C=ctenophores, J=jellyfishes

		Plankton		Dredge		Trawl		Interviews	
Area	Species	Samples	+ Observations	Samples	+ Observations	Samples	+ Observations	Total	pos.
October 1972									
1		17	1			17	1		
	C		1						
	J						1		
2			19			25	24		
	C	27	19				3		
	J						22		
3						1			
	C	5						4	1
	J								
4		9	2			9			
	C		2						
	J								
5			2			8			
	C	8	2						
	J								
Totals		66	24			60	25	4	1

Table 14. Sampling effort by month, type, area, and whether positive (+) or negative observations were obtained for a specific study area. C=ctenophores, J=jellyfishes

November 1972

		Plankton		Dredge		Trawl		Interviews	
Area	Species	Samples	+ Observations	Samples	+ Observations	Samples	+ Observations	Total	pos.
1		16				16	2		
	C								
	J						2		
2		24	7			24	19		
	C		7				3		
	J						19		
3		6				6	1		
	C								
	J						1		
4		10	1			10			
	C		1						
	J								
5		7				7			
	C								
	J								
Totals		63	8			63	22		
	C		8				3		
	J						22		

Table 15. Sampling effort by month, type, area, and whether positive (+) or negative observations were obtained for a specific study area. C=ctenophores, J=jellyfishes

December 1972									
		Plankton		Dredge		Trawl		Interviews	
Area	Species	Samples	+ Observations	Samples	+ Observations	Samples	+ Observations	Total	pos.
1		3				3			
	C								
	J								
2		15	6	1		15	4		
	C		6				1		
	J						4		
3		1							
	C					1			
	J								
4		10		4		10			
	C								
	J								
5		7		5		7			
	C								
	J								
Totals		36	6	10		36	4		
	C		6				1		
	J						4		

BY AREA: The distribution of medusae or adult ctenophores and jellyfishes encountered is depicted in Figs. 6-16 and Tables 16-17.

Area 1. Albemarle Sound harbored no coelenterates and few ctenophores. Croatan Sound possessed some Mnemiopsis leidyi in June and Chrysaora quinquecirrha in August. Note the influence of high oceanic waters intrusion via Oregon Inlet and the absence of jellyfishes and ctenophores in the adjacent Pamlico Sound (Figs. 10, 12-14). Nemopsis bachei occurred abundantly in February, at all levels, throughout Croatan. This was expected of this northerly winter form (Miner, 1950).

Table 16. Jellyfish occurrence, 1972, by Area

Month	Area 1	2	3	4	5
J	-	(X)	-	-	-
F	(X)*	X	-	-	-
M	-	X	-	-	-
A	(X)	X	-	-	-
M	(X)	X	-	-	-
J	(X)	X	-	-	-
J	-	X	-	-	-
A	(X)	X	(X)	-	(X)
S	(X)	X	(X)	-	(X)
O	(X)	X	-	-	-
N	(X)	(X)**	(X)	-	-
D	-	(X)**	-	-	-

(X)* Nemopsis, (X)** Rhopilema, (X) few, X present

Area 2. Area 2 was the most prolific in numbers of species of coelenterates as well as volumes and numbers of each species (Figs. 6-16). Their distribution was influenced by environmental factors as well as the natural interrelationship of jellyfishes preying on ctenophores (Cargo and Schultz, 1967; Heinle, 1966; Miller and Williams, 1972). This was most vividly detected and noted in Figs. 10-14 for June-October 1972.

Coelenterates abounded throughout all portions of Area 2 except for Core Sound. The extent of freshwater in Croatan Sound (Figs. 6-16) determined their entry into Croatan Sound (Figs. 6-16). As the jellyfish populations reached their summer peaks, the grazing of ctenophores by jellyfishes apparently accounted for their August and September distribution patterns more than environmental factors. This "tug-of-war" was most vivid in Figs. 12-14. As the fall water temperatures dropped to kill off Chrysaora (Cargo and Schultz, 1966) the ctenophore population of Mnemiopsis leidyi surged, except for those regions of extreme high oceanic waters near inlets (Fig. 14), back into abundance throughout all of Area 2.

Table 17. Ctenophore occurrence, 1972, by Area

Month	Area 1	2	3	4	5
J	-	X	X	-	-
F	(X)	X	-	-	-
M	-	X	X	-	(X)
A	X	X	X	-	(X)
M	X	X	-	-	(X)
J	-	X	(X)	-	(X)
J	(X)	X	(X)	(X)	-
A	-	X	-	(X)	(X)
S	-	X	(X)	-	(X)
O	(X)	X	-	(X)	(X)
N	-	X	-	(X)	-
D	-	X	-	-	-

(X) = few X = present

Area 3 was a virtual coelenterate-ctenophore "desert". A few Mnemiopsis, however, were encountered in August, October, and November (Figs. 12, 14, 15).

Area 4. Except for scattered ctenophores this area was likewise a barren of coelenterates and ctenophores.

Area 5. This area also possessed limited and sporatic occurrences of ctenophores.

BY SPECIES: Nemopsis bachei, a northern form (Miner, 1950) was encountered only in the Croatan Sound portion of Area 1. This small 25 mm diameter species abounded there in February.

Chrysaora quinquecirrha first appeared in the western end of Area 2, Pamlico Sound, in April as medusae 1.6 mm in diameter. Within weeks their abundance and size enlarged until, by late April, they were encountered as individuals with 60 mm bell diameters. Large specimens 240 mm were not evident or abundant throughout the area until July. The only known natural predators of the medusae stage are sea turtles (Schwartz, 1967) or some fish (Cargo, 1962).

Aurelia aurita occurred, on occasion, in August and September in Area 3, Newport River, and in the Atlantic Ocean along the beach waters from Cape Lookout to Cape Fear. Elsewhere specimens 355-457 mm in diameter were often encountered, but at no time were they abundant.

Rhopilema verrilli which has been previously recorded from Pamlico Sound in August (Miner, 1950) was not captured until November and December 1972 (Figs. 15-16). Wysocking Bay and Ocracoke Channel produced the four specimens

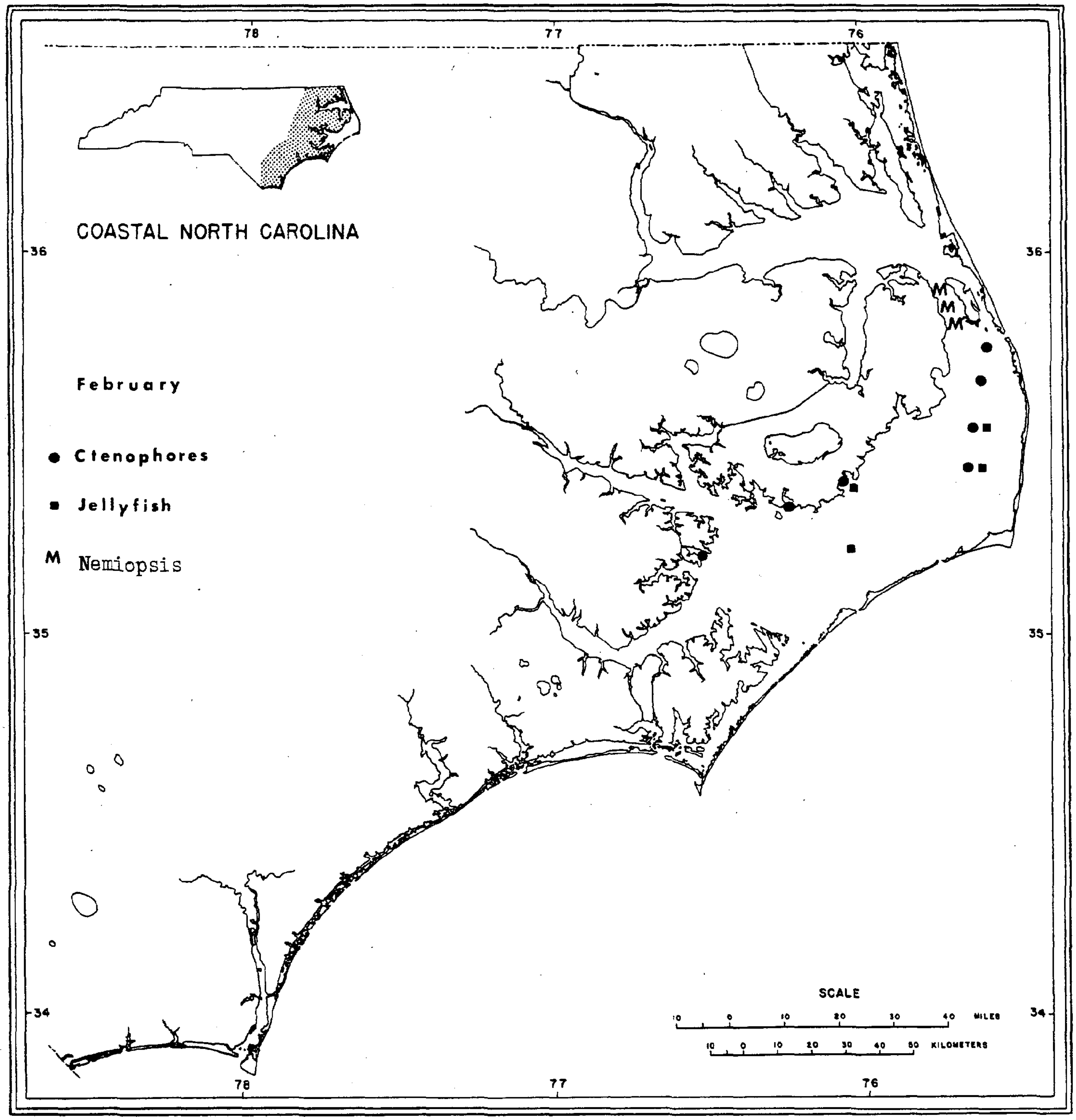


Figure 6. A map of coastal North Carolina illustrating coelenterate-ctenophore collections.

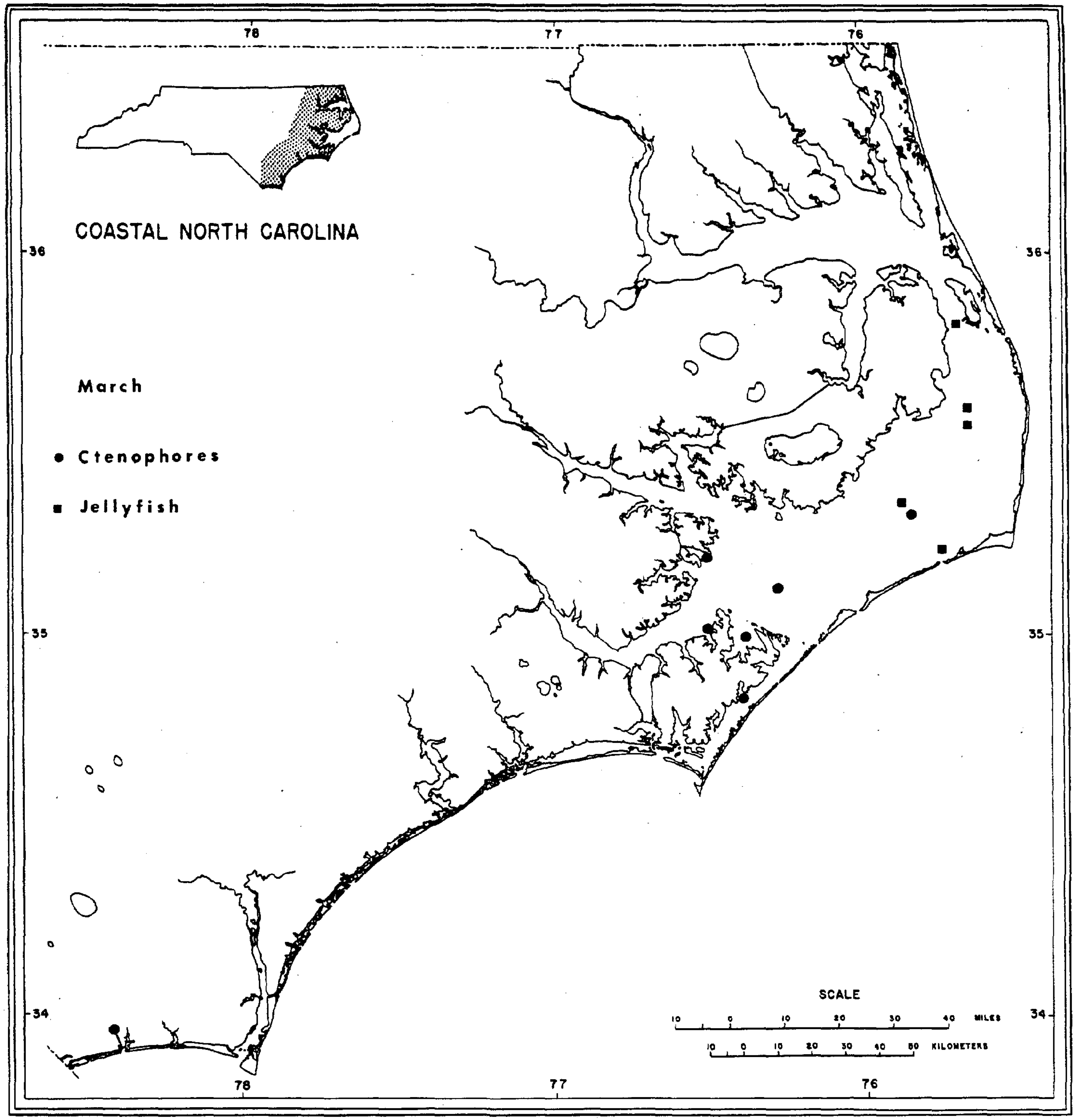


Figure 7. A map of coastal North Carolina illustrating coelenterate-ctenophore collections.

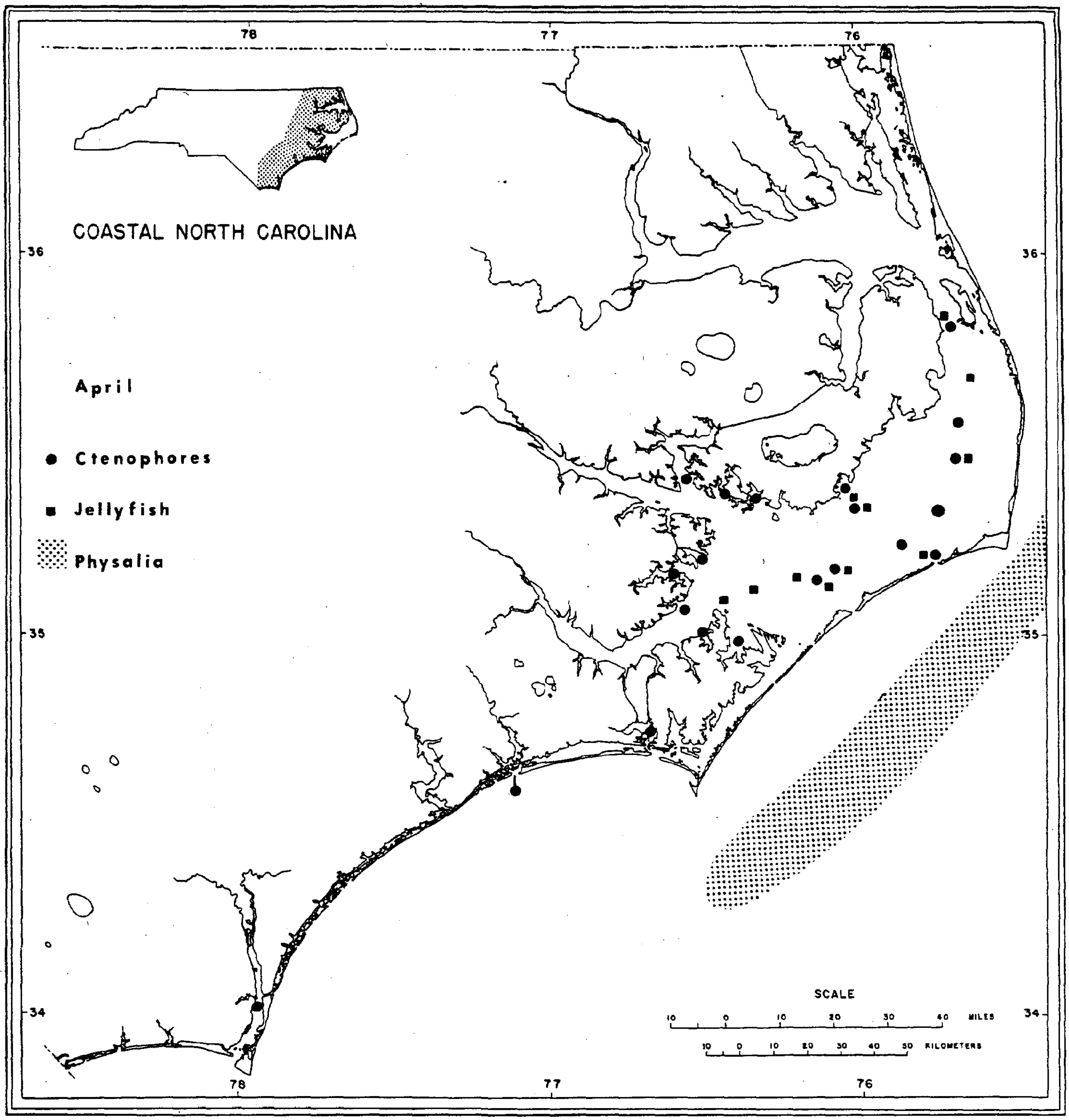


Figure 8. A map of coastal North Carolina illustrating coelenterate-ctenophore collections.

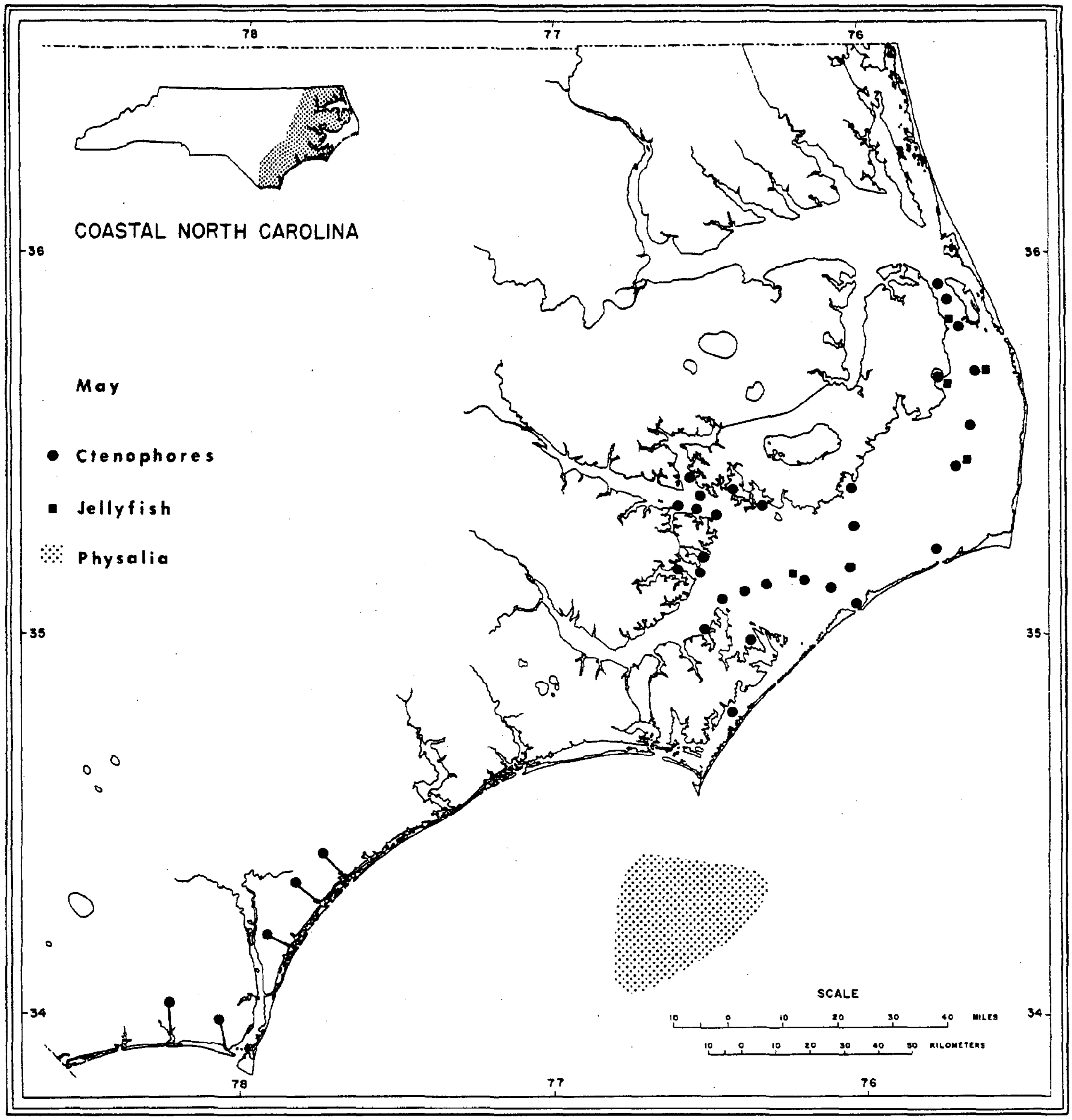


Figure 9. A map of coastal North Carolina illustrating coelenterate-ctenophore collections.

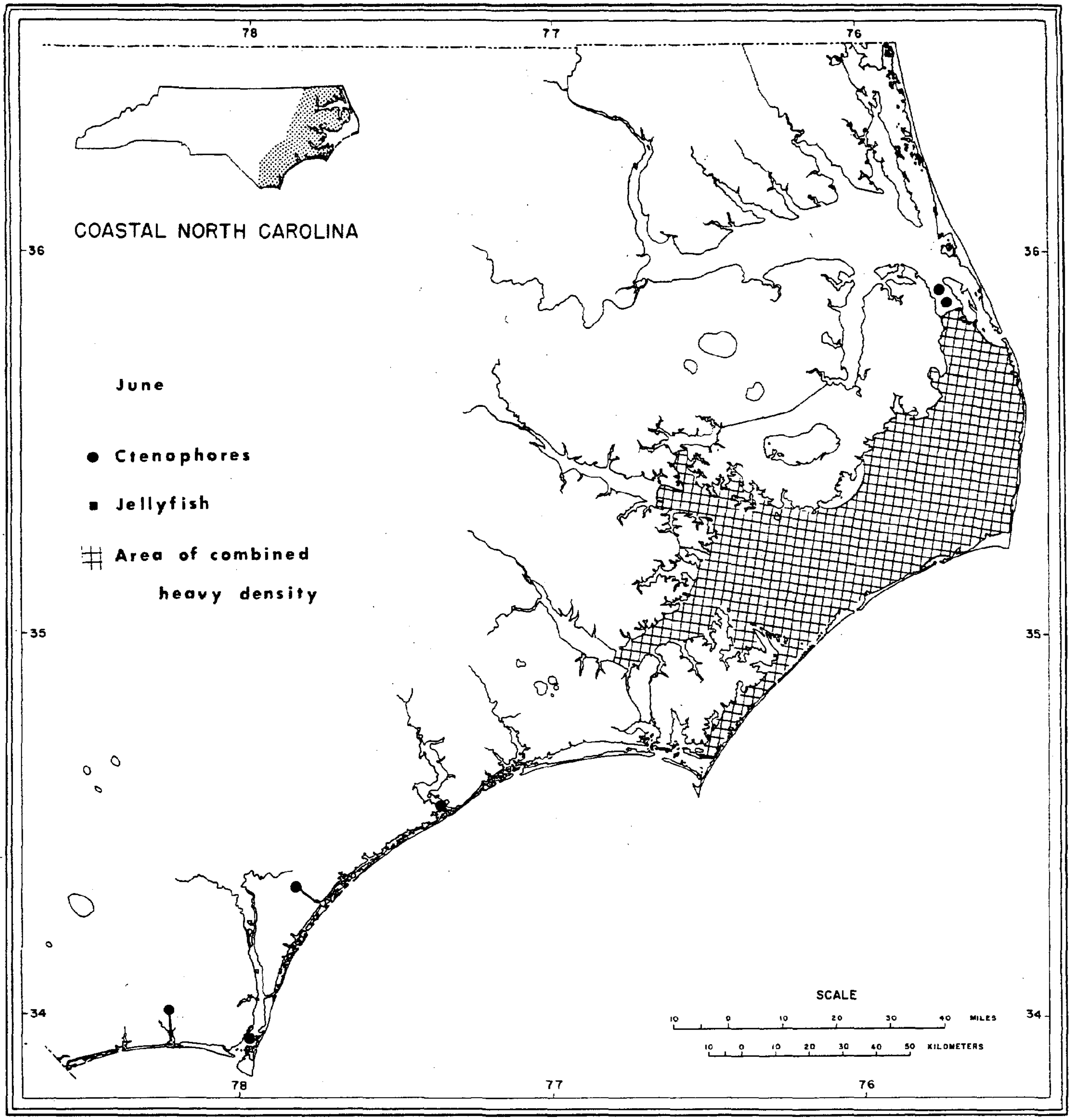


Figure 10. A map of coastal North Carolina illustrating coelenterate-ctenophore collections.

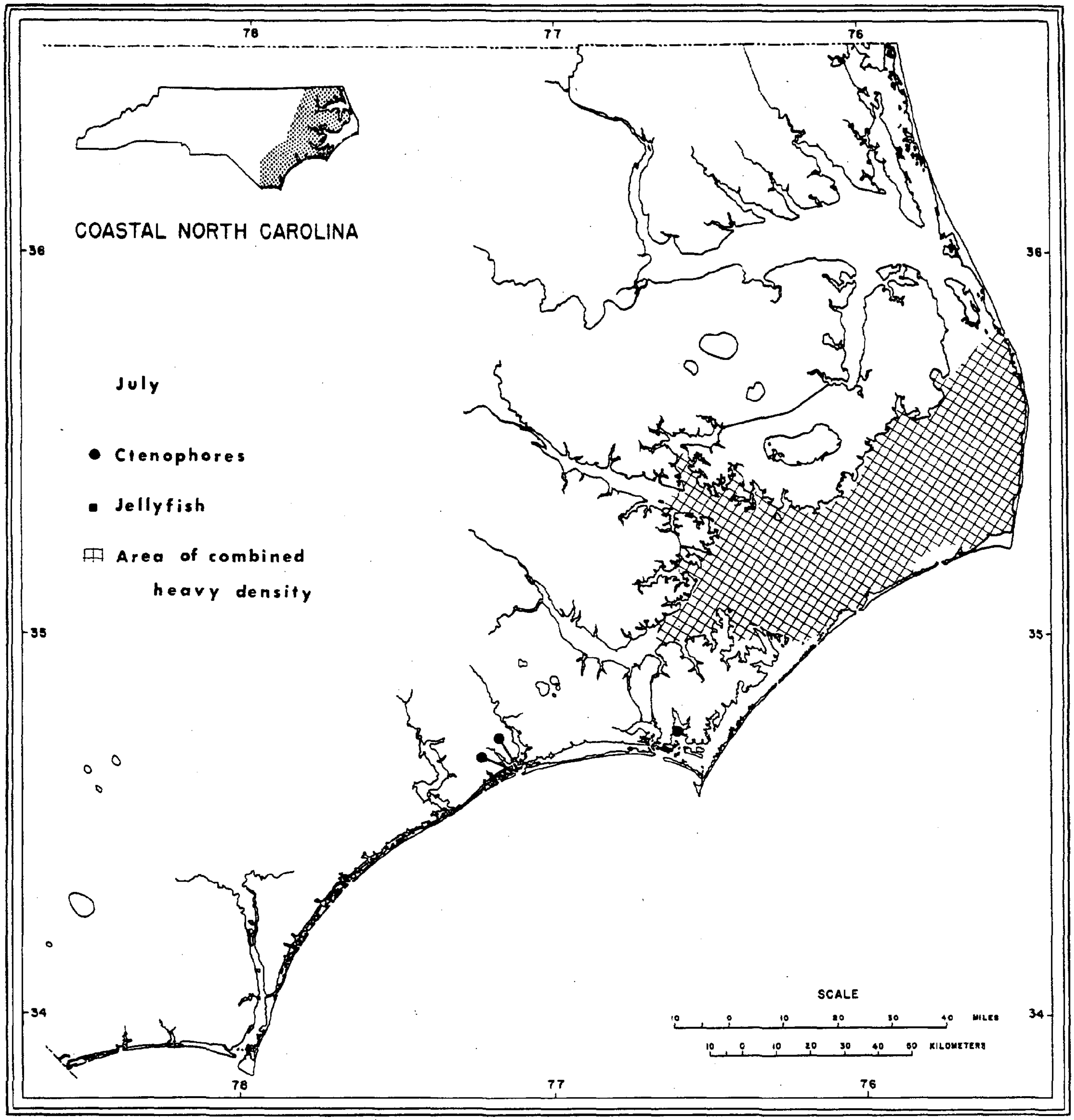


Figure 11. A map of coastal North Carolina illustrating coelenterate-ctenophore collections.

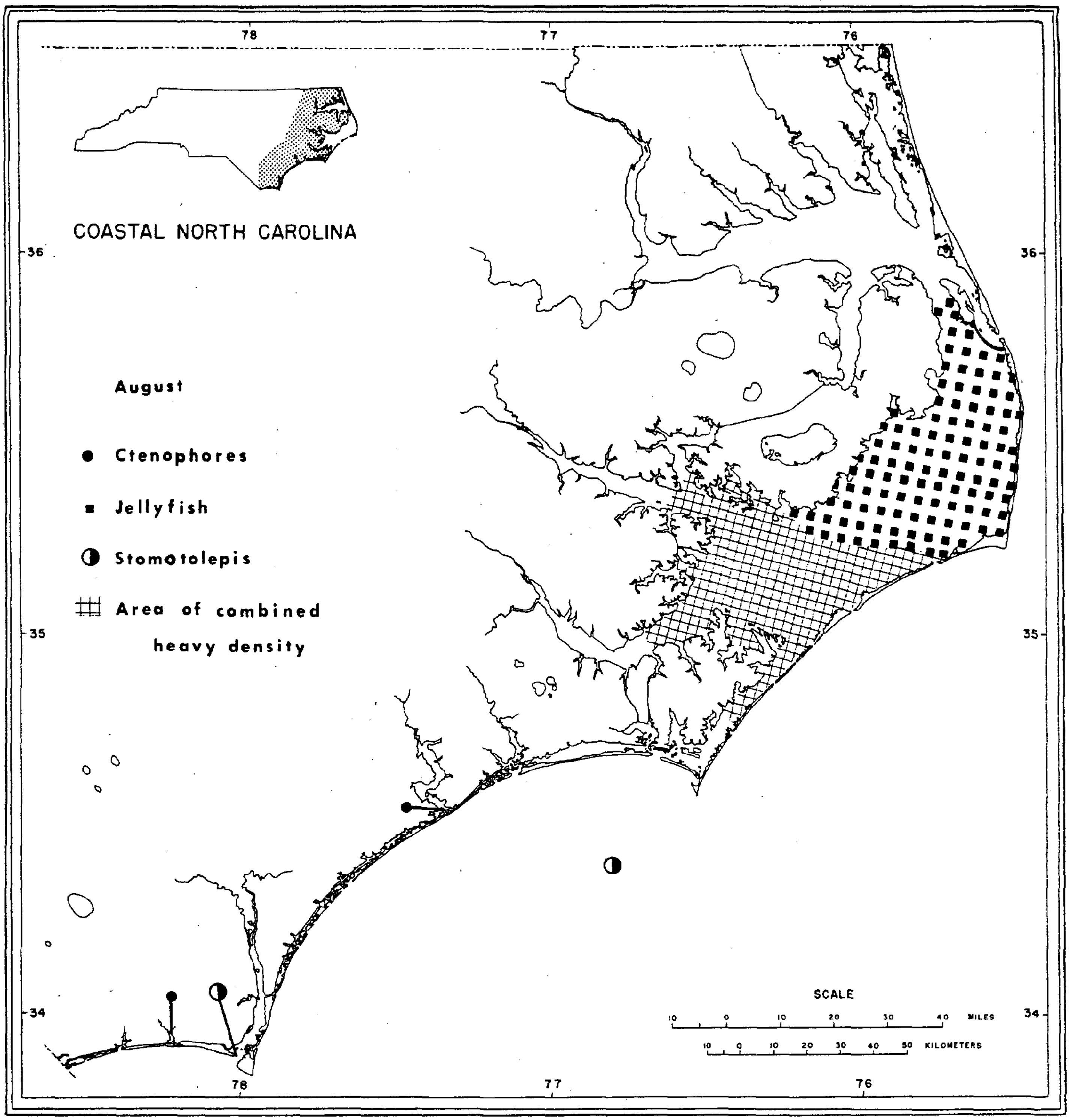


Figure 12. A map of coastal North Carolina illustrating coelenterate-ctenophore collections.

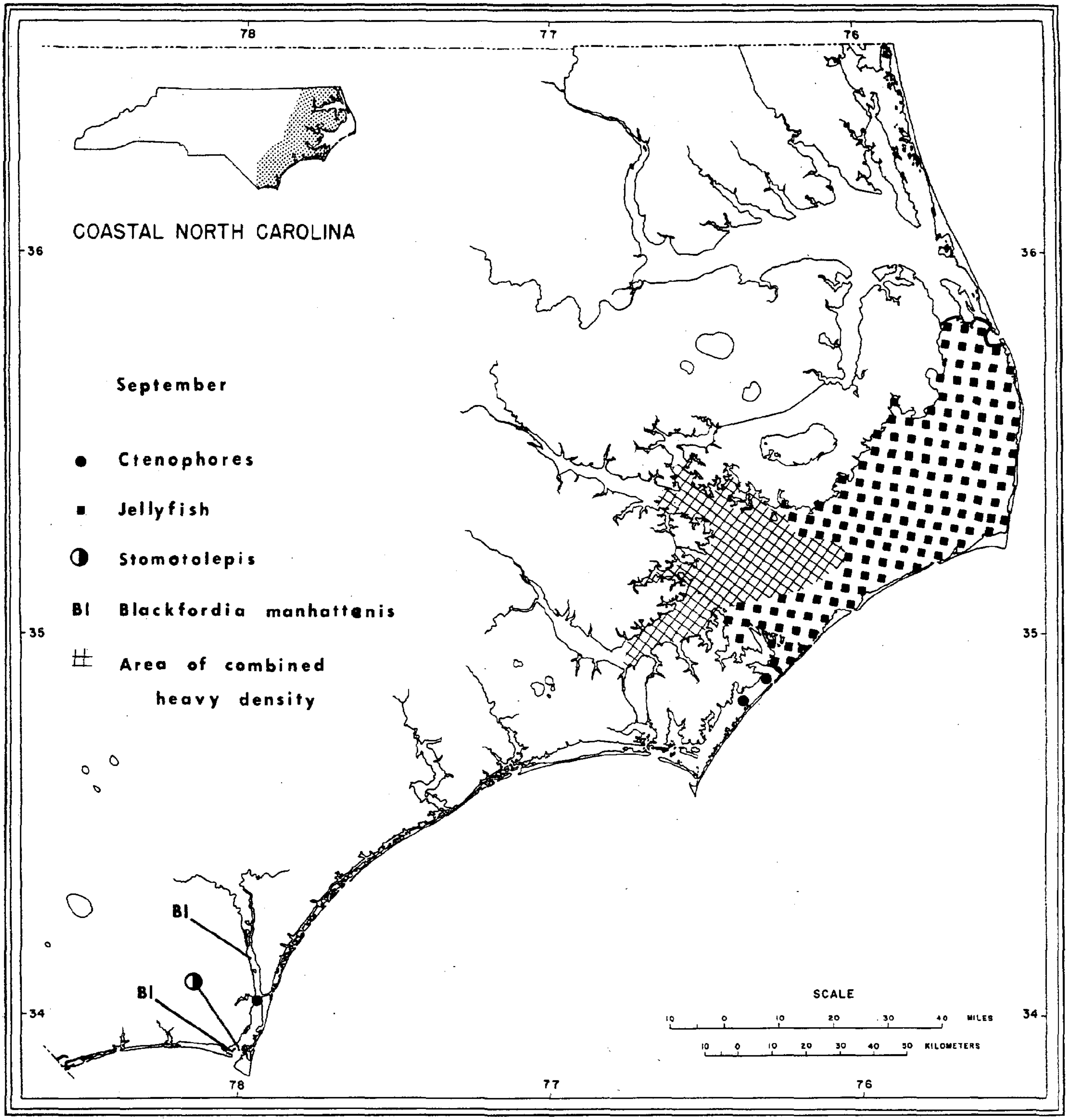


Figure 13. A map of coastal North Carolina illustrating coelenterate-ctenophore collections.

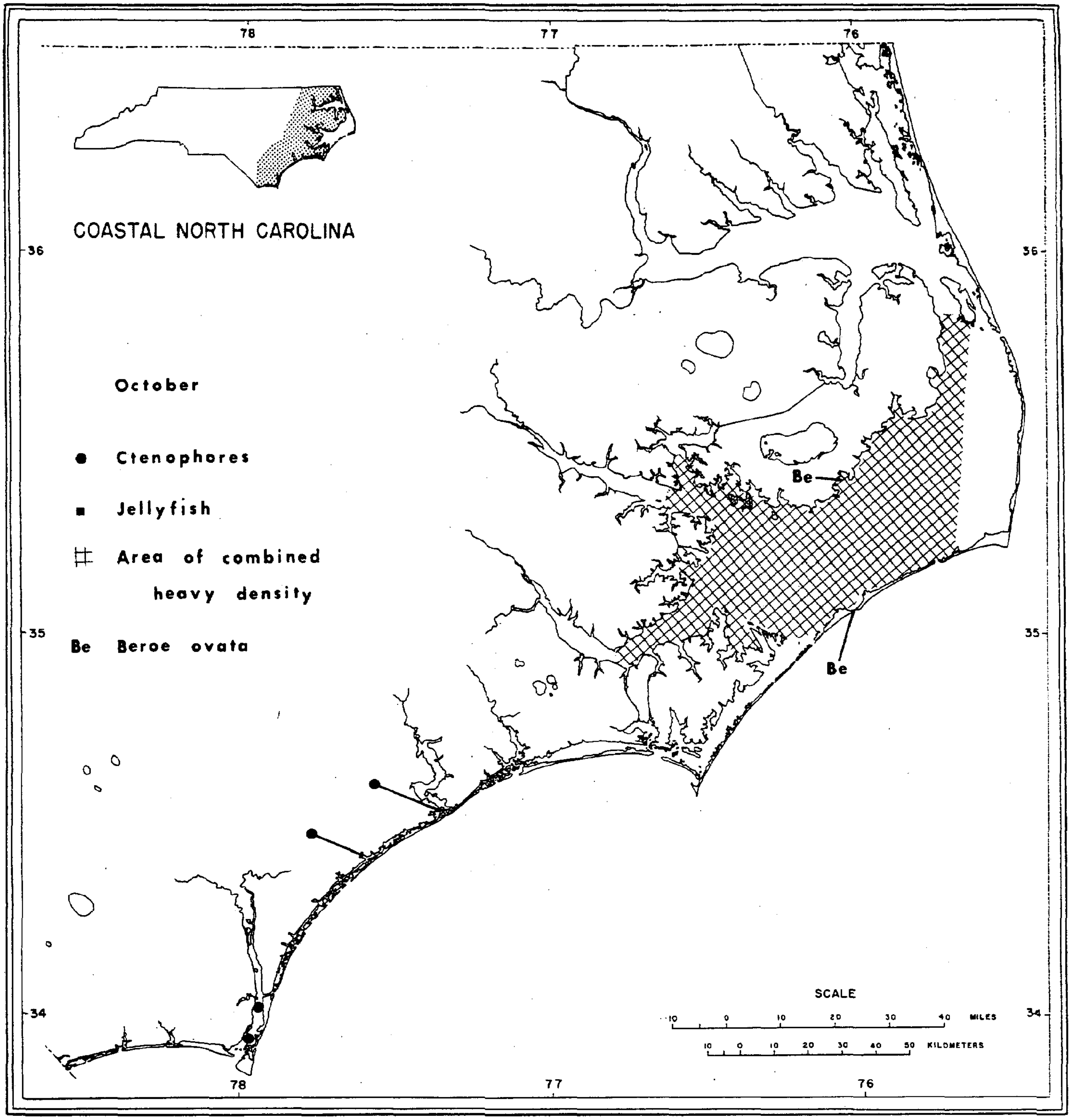


Figure 14. A map of coastal North Carolina illustrating coelenterate-ctenophore collections.

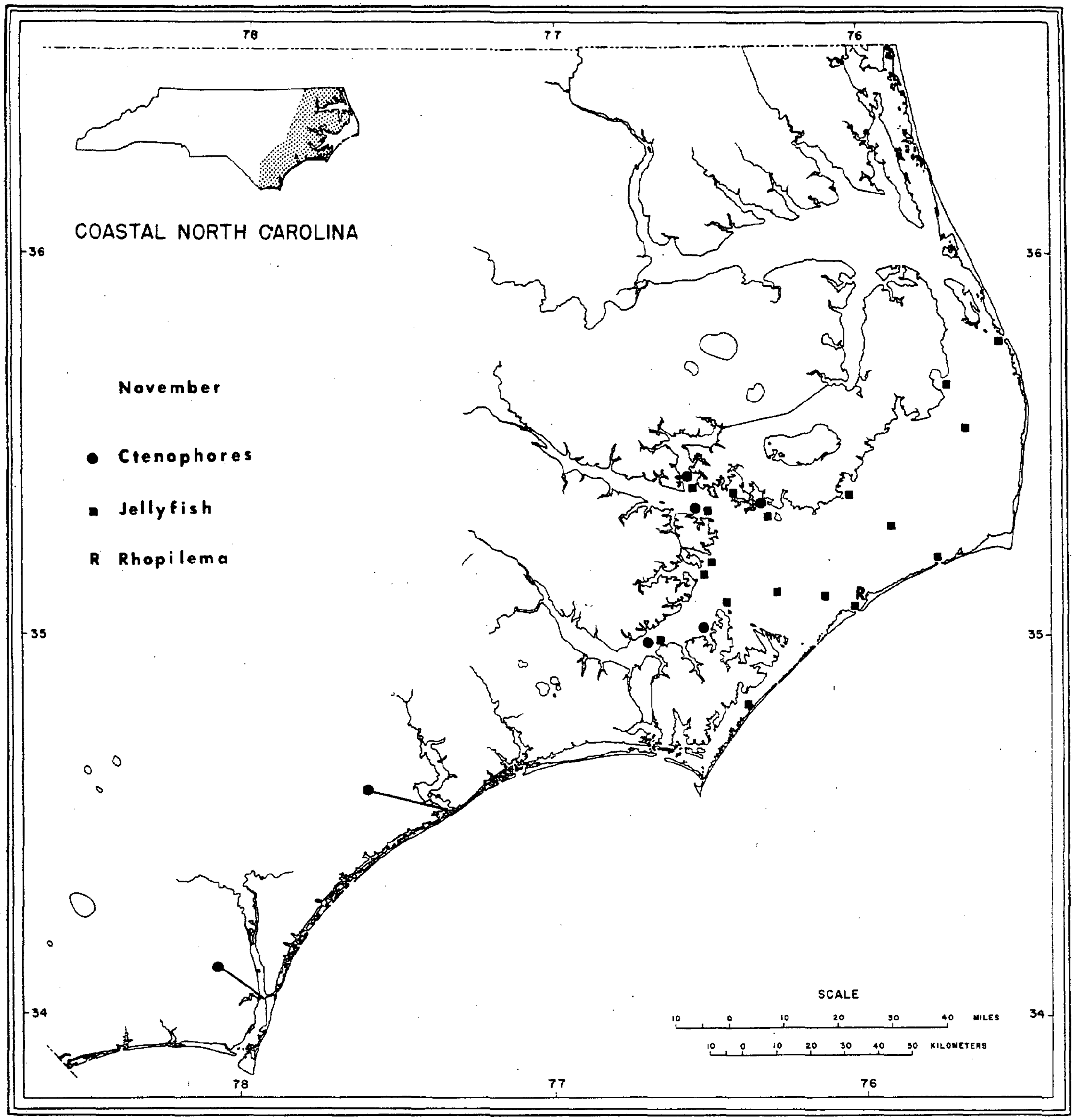


Figure 15. A map of coastal North Carolina illustrating coelenterate-ctenophore collections.

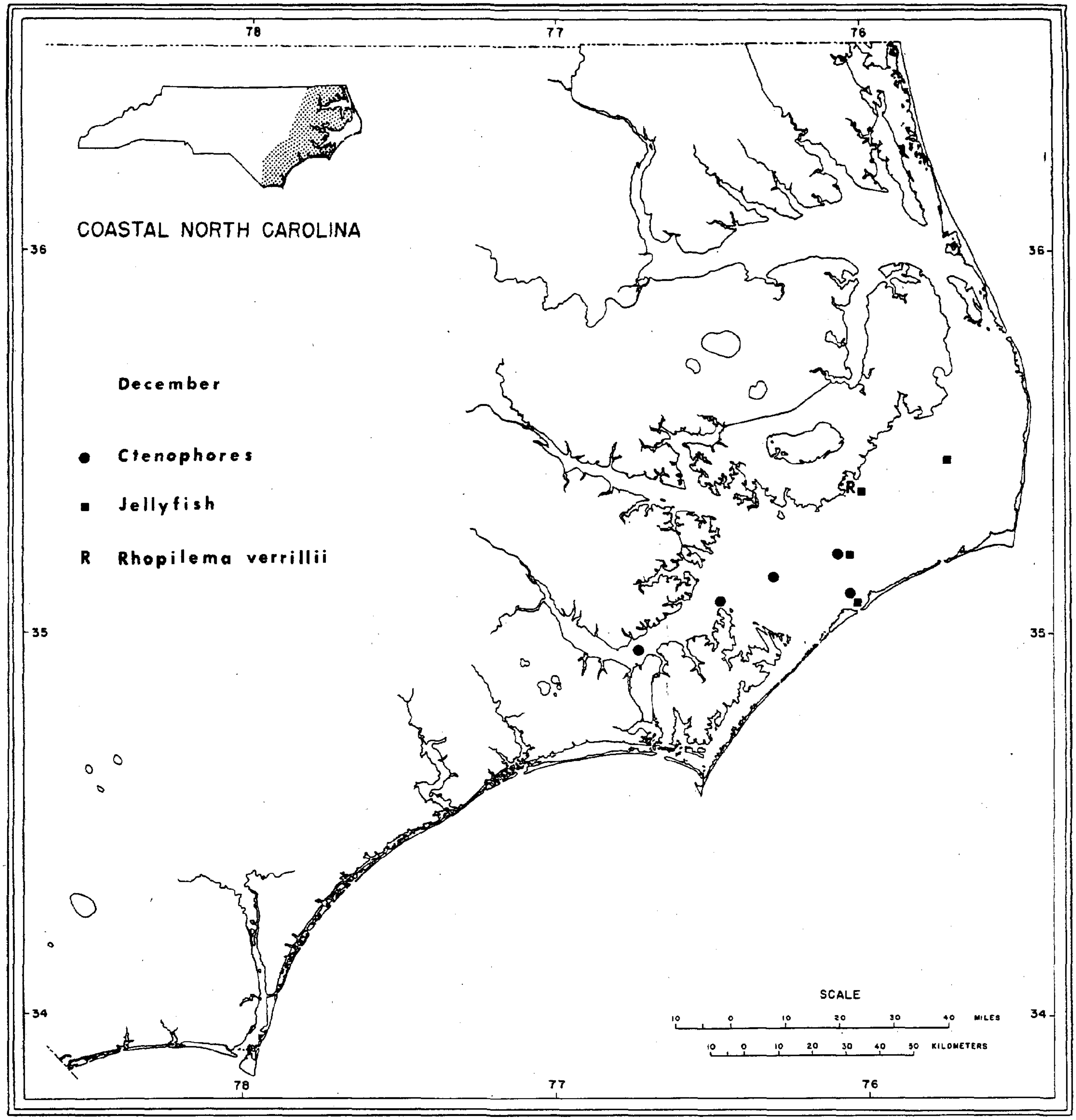


Figure 16. A map of coastal North Carolina illustrating coelenterate-ctenophore collections.

obtained. Those at Ocracoke's Big Foot Slough Channel were enormous, measuring some 457-508 mm in bell diameter.

Physalia sp. was observed as early as April (Fig. 8) while aboard various vessels, occurring from the 185 m depth seaward. Their abundance prevailed until May (Fig. 9), and undoubtedly was replenished, throughout the summer, by the nearby Gulf Stream. Specimens 102-152 mm float length were abundant even during severe wind and wave conditions. Northeast winds apparently drove this Gulf Stream transport onto the beaches from Morehead City to Wrightsville Beach in April, when the greatest incidences of medical stings were reported.

Stomolophus and Blackfordia. The most exciting finds were the capture of two poorly known species in August and September 1972. Several 76 mm diameter Stomolophus meleagris were captured at the mouth of the Cape Fear River (Figs. 13-14). Note the one August capture on the scallop grounds 22.2 km offshore (Fig. 13). Since this study, great masses of adult Stomolophus occurred from the South Carolina line at sea and in the sounds south of Hatteras between April and November 1973. Dense samples of Blackfordia manhattensis were taken in September just below Wilmington and at the mouth of the Cape Fear River (Fig. 14).

Mnemiopsis leidyi was the common ctenophore encountered. It occurred as adults throughout all seasons, being most abundant, however, in the western portion of Area 2 (Figs. 6-16). Their distribution was affected by environmental factors as well as the cropping they received by Chrysaora quinquecirrha (Figs. 12-13). It is believed they are serious predators of zoo- and phytoplankters (see survey in Miller and Williams, 1972; and Bishop, 1967, 1968, 1972). Cargo (1962) cites their being eaten by the fish Peprilus paru (alepidotus).

Beroe ovata, a winter form of ctenophore, was found only sparingly in October at Wysocking Bay and at Ocracoke Inlet (Fig. 14). Why it didn't persist or proliferate throughout the remainder of the winter months is unknown. It has been retaken in samples in Area 1 in February 1973, and in Area 5, Cape Fear River in November 1973.

BY TYPE OF GEAR:

Otter trawls and plankton nets were the most indicative of coelenterate presence, abundance, and location. Since all coelenterates, as adults, are subject to winds and currents, on those days when surface weather conditions were bad the trawl yielded more individuals than the surface towed plankton nets. The reverse was true when conditions were calmer or water currents less violent.

As part of another project, where gill nets were being used after July, the vertical distribution of jellyfishes was noted on gill nets that were set from surface to bottom and subject to water currents and conditions.

Rough weather conditions found more jellyfishes enmeshed in the lower portions of each net while calmer conditions found them in the upper meshes of the nets.

Dredge. Oyster dredge samples, during the cold spring and winter months of 1972, yielded oysters and oyster shells with varying number of polyps and cysts The highest incidences occurred in Area 2, Pamlico Sound. Only one polyp was found on shells outside of Area 2. This was in Area 5 at Lockwoods Folly. All other beds sampled were negative (Fig. 17).

Most Chrysaora polyps and cysts occurred in an arc spanning the western portion of Pamlico Sound, Area 2. Highest incidences occurred in February and March in South River, Turnagain Bay, with diminishing amounts in Bay River, Rose Bay, and Swanquarter Bay (Fig. 17).

The high incidence of Chrysaora quinquecirrha cysts and polyps coincided with the areas of highest seasonal occurrence and distribution of the jellyfish in Pamlico Sound. The attached polyp-cysts can, therefore, be considered the reservoir area for summer abundances of it's medusae stage. Note from figs. 6-16 that the ctenophore Mnemiopsis leidyi was also encountered more often in the same arc zone that the Chrysaora polyps and cysts were. Other factors of salinity, however, help explain this preference of Mnemiopsis to western portions of Pamlico Sound.

Fall and winter (through December 1972) samples of the same oyster beds, throughout all areas, failed to yield any Chrysaora polyps or cysts. It is believed water temperatures and salinities were not optimum for their development (Cargo and Schultz, 1967). Termination of the project in December, with no funding continuation, prevented sampling in February-March 1973 when conditions would have been more suitable for their existence.

Relation to environmental factors:

Temperature: Chrysaora medusae were most abundant (Figs. 10-14, 18) during the summer and fall months when water temperatures were 25° C or higher. Note that as the fall water temperatures dropped (Figs. 3-5), the number of medusae (in terms of volume) decreased drastically (Figs. 15-16, 18).

Ctenophores (Figs. 10-14, 20) likewise were most abundant when water temperatures were above 25° C, the exception being Nemopsis bachei for February in Croatan Sound, Area 1.

Salinity: Chrysaora was most abundant (Fig. 19) in waters of salinities of 15-20 ppt (Figs. 3-5). This helped explain their absence during influxes of high oceanic waters at Ocracoke, Hatteras, and Oregon inlets (Figs. 10, 12-14). These observations are corroborated by the ferry boat and bridge personnel observations where no or few coelenterates were noted in the low or high salinity waters occurring in their observations areas (Table 18).

Oxygen: Since abundant amounts of oxygen were present at all levels in all areas of the study, we believe this facet was not as influential to coelenterate and ctenophore distribution or abundance as wind, wave currents,

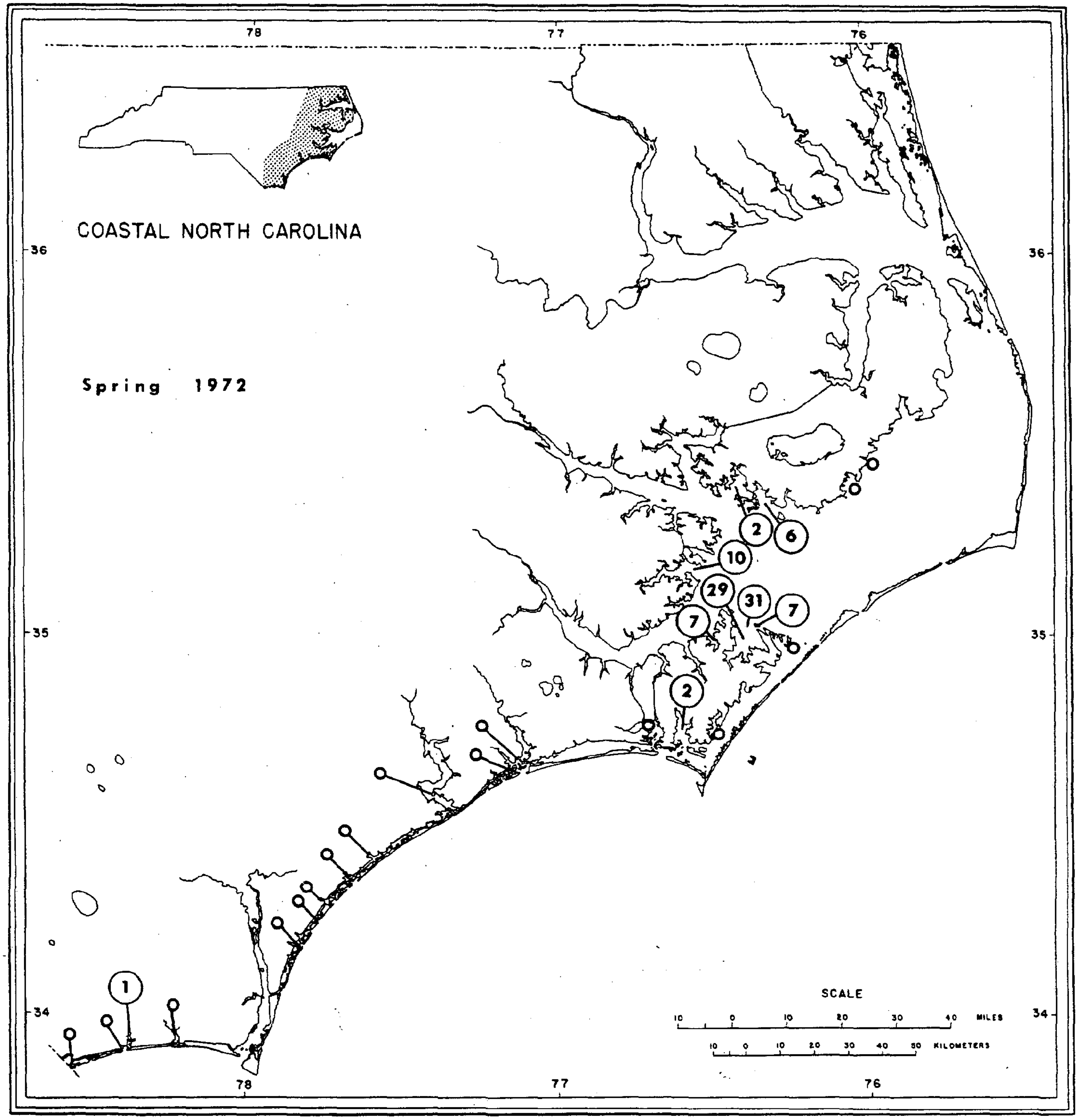


Figure 17. Incidence of Chrysaora polyp or cysts found associated with oyster, oyster shells or marl, sample volume was a 11.5 liter pail.

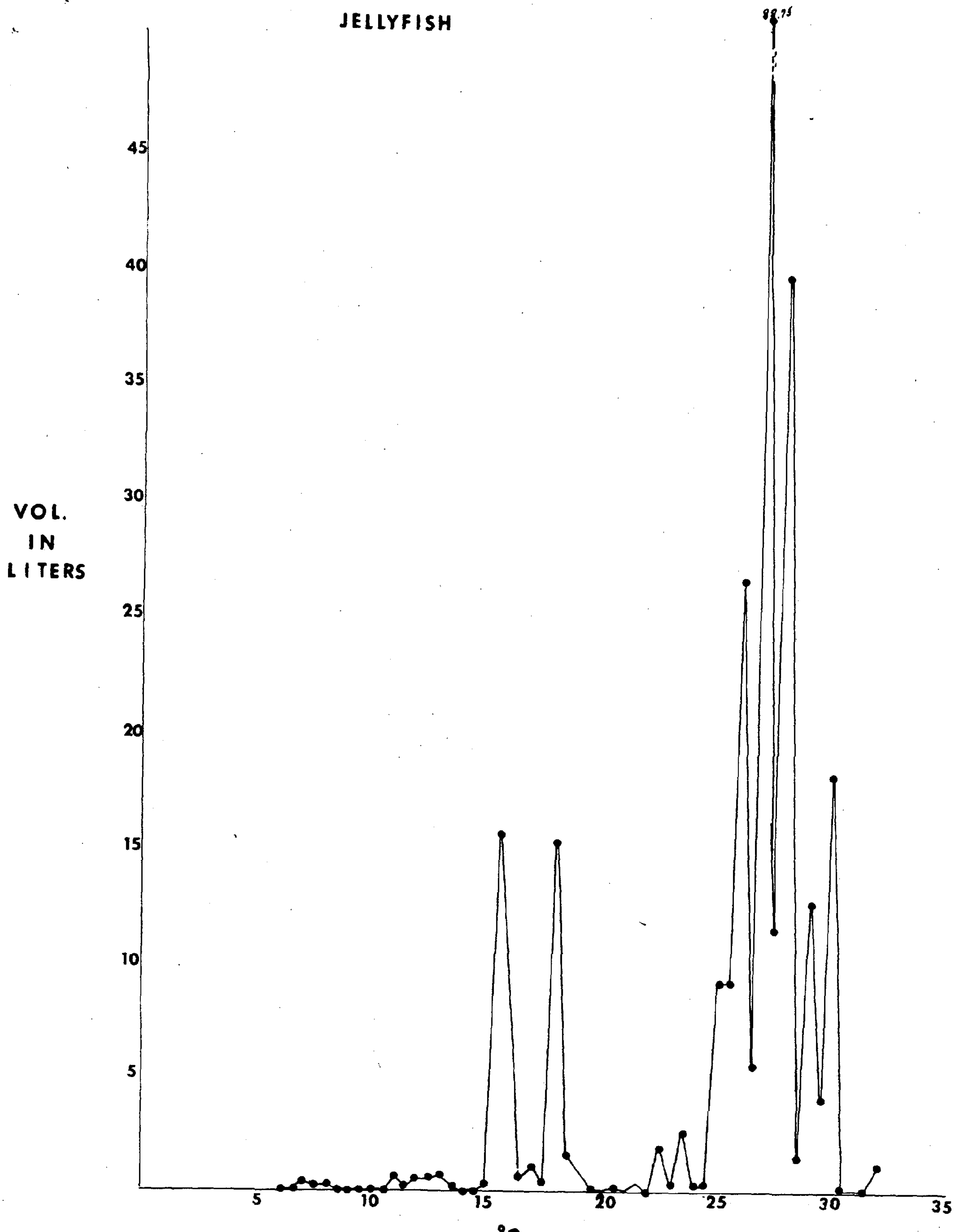


Figure 18. Relationship of temperature to volume in liters of jellyfish regardless of area, 1972.

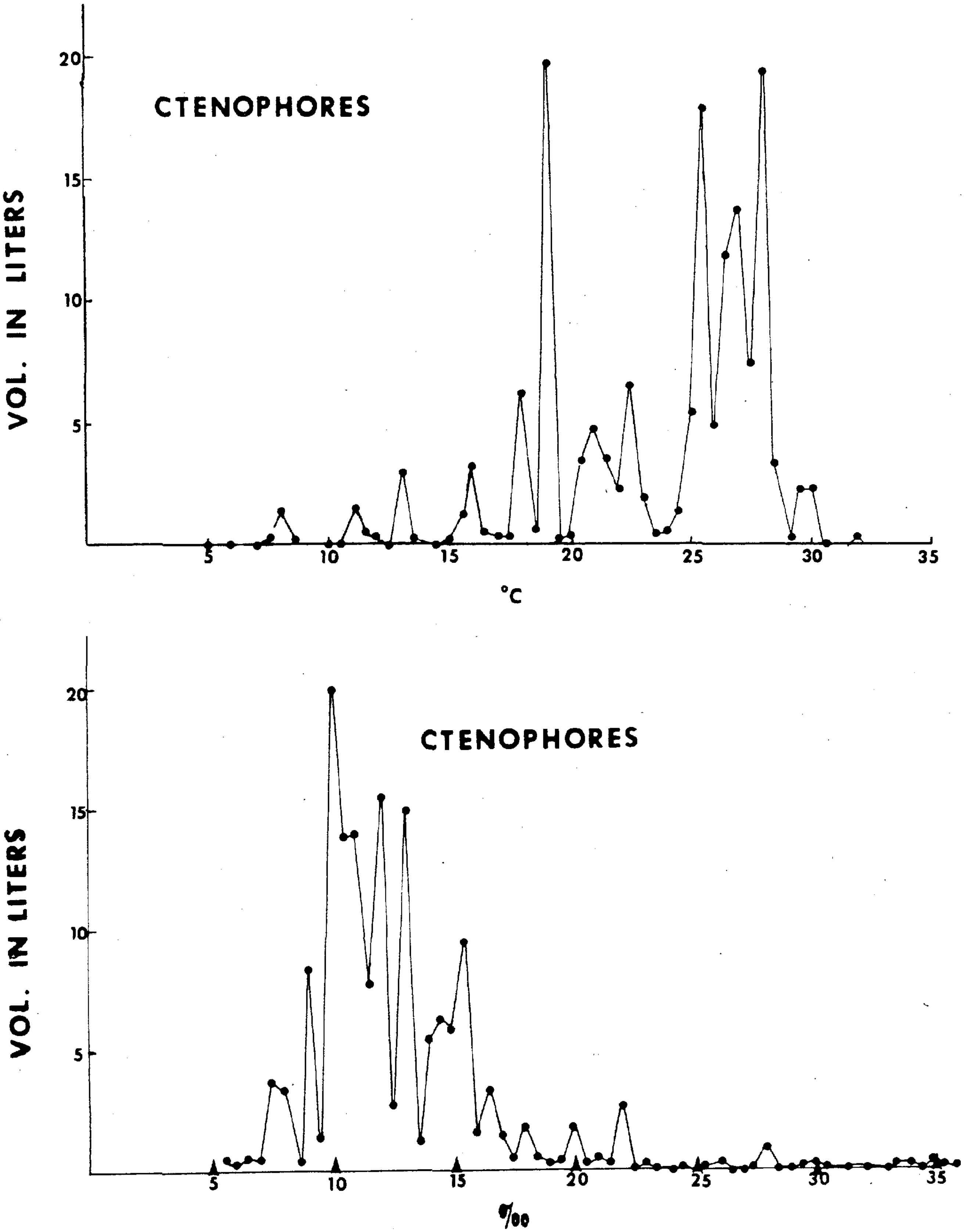


Figure 19. Relationship of temperature and salinity to volume in liters of ctenophores regardless of area, 1972.

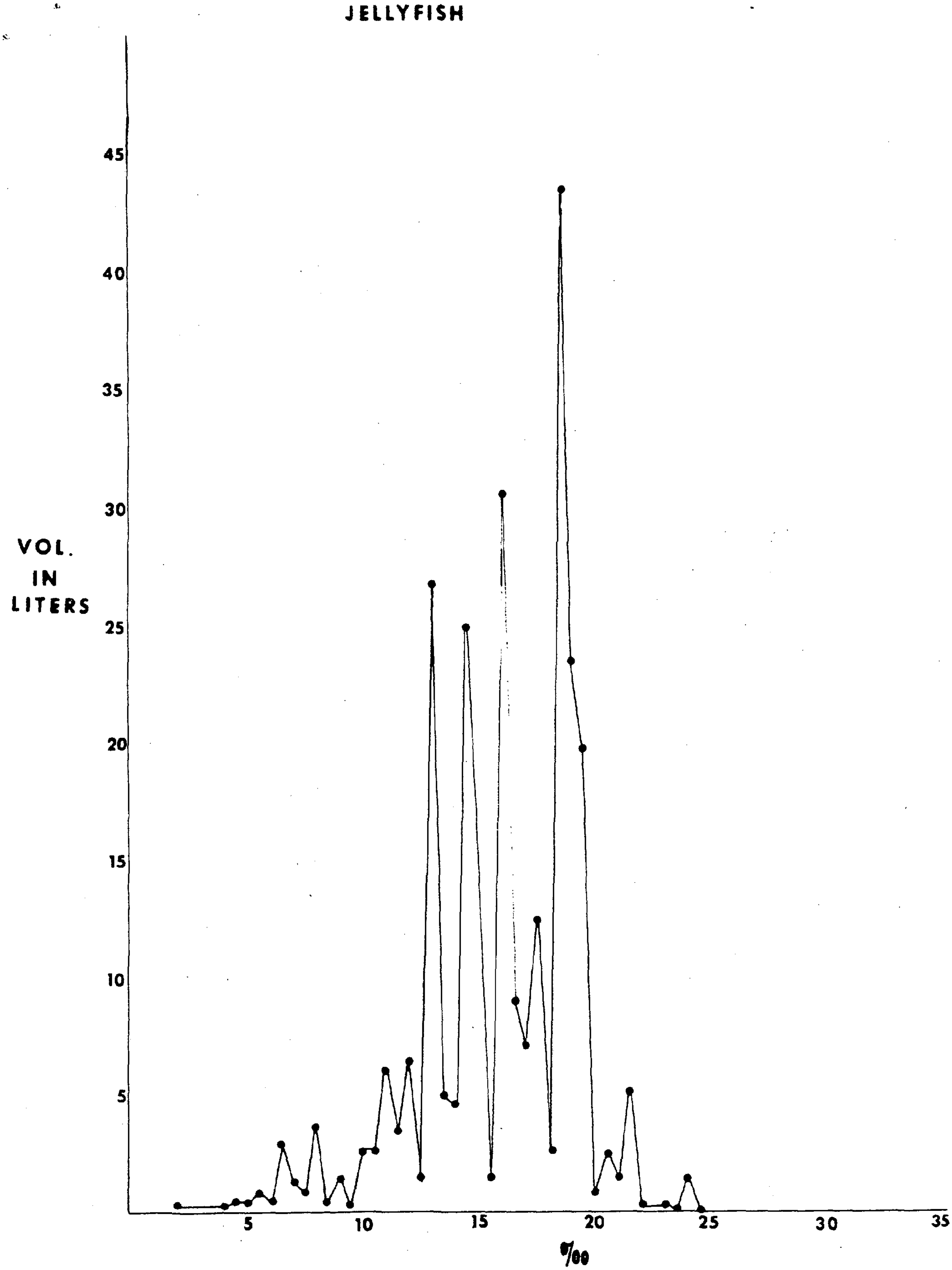


Figure 20. Relationship of salinity to volume in liters of jellyfish regardless of area, 1972.

water temperatures, or salinities.

Associated species:

Fishes: The organisms most frequently captured or possibly affected by abundances of coelenterates and ctenophores were fishes. Eighty-five species of fishes (Table 19) were captured throughout the five areas. Each area (Fig. 1) possessed a fauna slightly more unique to that area than another.

It is interesting that for the months of April and October, trawl catch data did not substantiate the local folk lore beliefs that during these months fishes were supposed to be moving into or out of the sounds and estuaries in earnest (Table 20). By area, Area 2, Pamlico Sound yielded the greatest number (Table 20) and species of fishes. Area 1 was likewise productive, considering its nearly freshwater status.

Areas 3, 4, 5, were surprises as one would have expected them to be rich with oceanic-estuarine fishes. Core Sound, Area 3, possessed a sparce fish population but apparently serves as an occasional route for fish movements. This was strange in the light of the known fall fishery for *Mugil cephalis* and *C. regalis* and the summer gig and seine fishery for flounders, *Paralichthys*, mostly *lethostigma*.

Table 18. Monthly Observations by ferry boat (F) and bridge (B) personnel during 1972 of jellyfish and ctenophore occurrence.

Locality	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Neuse River (F)		C 3/30*	C 1/30	C 4/30			
Atlantic Beach - Bogue Sound (B)		0/5	0/31	0/30	0/31	0/30	
Cedar Island (F)		P 1/31	Ct 1/31	0/30	0/31	0/30	0/15
Ocracoke (F)	C 6/30	0/31	P 3/30	C 3/30	0/31		
Harkers Island-Straits (B)		Ct-P 1/31	0/31	0/30	0/31	0/30	0/31
Beaufort Rt 70 Bridge (B)		0/31	0/31	0/30	A 1/31	0/30	0/31
Pamlico River (F)	0/30						

C = Chrysaora, Ct = Ctenophore, A = *Aurelia*, P = *Physalia*
*positive occurrences/days of observations

Table 19. List of fish species collected in 1972 from coastal North Carolina irrespective of area sampled.

Alosa aestivalis
Alosa mediocris
Alosa pseudoharengus
Alosa sapidissima
Aluterus schoepfi
Aluterus scriptus
Anchoa hepsetus
Anchoa mitchilli
Ancylopsetta quadrocellata
Anguilla rostrata
Archosargus probatocephalus
Arius felis
Astroscopus y-graecum
Bairdiella chrysaora
Brevortia tyrannus
Carynx hippos
Centropristes philidelphicus
Centropristes striata
Chaetodipterus faber
Chasmoides sp.
Chilomycterus schoepfi
Citharichthys sp.
Cynoscion nebulosus
Cynoscion regalis
Dorosoma cepedianum
Elops saurus
Etropus sp.
Eucinostomus gula
Gobionella boleosoma
Gobiesox strumosus
Gobiosoma sp.
Gymnura micrura
Hippocampus erectus
Hypopleura sp
Hypsoblennius hentz
Ictalurus catus
Ictalurus punctatus
Ictalurus sp.
Lagodon rhomboides
Leiostomus xanthus
Lepomis gibbosus
Lutjanus analis
Lutjanus synagris
Menidia menidia
Menticirrus sp.
Micropogon undulatus
Monocanthus hispidus
Morone americana
Morone saxatilis
Mugil sp.
Mycteroperca bonaci
Opisthonema oglinum
Opsanus tau
Orthopristis chrysoptera
Ostracion diaphanum
Paralichthys albigutta
Paralichthys dentatus
Paralichthys lethostigma
Peprilus alepidotus
Peprilus triacanthus
Perca flavescens
Pogonias chromis
Pomatomus saltatrix
Prionotus carolinus
Prionotus evolans
Prionotus scitulus
Prionotus tribulus
Rachycentron canadum
Raja eglanteria
Rissola marginata
Sciaenops ocellata
Scomberomorus maculata
Scophthalmus aquosus
Selene vomer
Sphoeroides maculatus
Stellifer lanceolatus
Stenotomus caprinus
Strongylura marina
Symphurus plagiusa
Syngnathus sp.
Synodus foetans
Trichiurus lepturus
Trinectes maculatus
Urophycis regius
Vomer setapinnis

Table 20. Fish trawl catch (total) by area, 1972

Month	Area 1	2	3	4*	5*
J	3793	1908	-	-	-
F	967	4428	-	15637	
M	507	8527	212	378	
A	2317	6756	42	202	
M	3097	13568	39	2492	
J	3693	12211	111	246	
J	2165	8742	0	729	
A	4184	8265	40	1478	
S	1656	9424	54	373	
O	4105	7925	0	62	
N	1649	5880	33	540	
D	---**	1429	0	646	
Total	28133	89063	531	22783	140510

*Areas 4 and 5 combined
**Samples ommitted due to boat's broken masts

Areas 4 and 5 were also devoid of fishes (Table 8). The high catch figure for February occurred at Bonaparte Inlet near the South Carolina line. Apparently an overwintering group of fishes had entered or was leaving the system via that inlet. At no other time did any one specific portion of Area 4 or 5 yield appreciable numbers of fishes. To prevent unwieldiness of this report, tables listing actual catches, sizes, and weights of each species for each of the 84 stations are available and on file at the Institute of Marine Sciences rather than as appendages to this report.

Crabs: The blue crab Callinectes sapidus was found in all areas but Area 1. Their abundance and size varied by season, sex, and location. The only pattern evident was the greater abundance near inlets in the fall and early spring.

Shrimps: Penaeids, especially brown spotted or pink shrimp were found in abundance in Area 2 from late April to late October and early November. Pamlico Sound is known to harbor an overwintering pink shrimp population (McCoy, 1968; Purvis and McCoy, 1972). Shrimp sizes were greatest during the period September to November.

Area 5 supports a summer and winter white and brown shrimp population that is of bait and commercial importance (McCoy, 1972). Some white shrimp seemed to be evident in Area 5 each month of the year. Grass shrimp of the genera Palaemonetes sp. and Crangon septemspinosa were common throughout all areas but Area 1. This agreed well with Williams and Deubler (1968).

Crangon, a deeper winter form, occurred from January-March and again in December 1972. Ovigerious females of Crangon were common during these months. Palaemonetes sp. were abundant during the summer months, especially in Areas 4 and 5, with ovigerious females being present during almost any but the severest cold months.

Other associates: An unusual population of Anomalocera ornata was encountered in the inland waterway between Carolina Beach and Topsail Beach inlets on 23 February 1972. This oceanic species described by Sutcliff from New River Inlet in 1949 occurred in such vast numbers that pure concentrations could be obtained in the plankton net or simply with a draw bucket. A five minute tow literally filled a meter plankton tow. McCreary (1972) sampling almost simultaneously found wind rows of Anomalocera along the same portion of the inland waterway and has noted their periodic ingress since 1966 (McCreary, pers. comm.) as well as in mid February 1973.

Literature Review

During the course of this study a literature compilation was prepared to many papers that dealt with the systematics, occurrence, zoogeography, evolution, biology, ecology, effects to man by coelenterates and ctenophores. This large compilation could have been part of this report had not toward the end of 1972 the Bibliography on the Scyphozoa, with Selected References on Hydrozoa and Anthozoa, been published by Calder, Cones, and Joseph. This publication made the effort of presenting much of our list here redundant.

Interviews

Another aspect of the 1972 coelenterate-ctenophore study was to assess their economic impact upon the commercial fishery, sport fishery, and tourist industries of coastal North Carolina.

Various approaches were utilized to assess the impact of coelenterates to North Carolina. Most were in the form of questionnaire or personal interview.

General public, commercial fisherman interview form: Some 1676 forms (Table 21) were sent out to the general public, commercial, and sports fishermen, with the majority to coincide with the first major incidence of jellyfish and ctenophore abundance. Return of the form, to which was appended (Table 22) a short designation and drawing of each of the believed naturally occurring species, was hoped would resolve much understanding by the public's encounter or reaction to coelenterates and ctenophores.

Area 1 received 35 interview forms. Only four were returned of which 25% indicated they felt coelenterates and ctenophores were a problem while most indicated they never saw a jellyfish or even realized there was a problem.

Area 2. Some 478 forms were sent. Again a low response was received. Of those responding, mostly commercial fishermen, 57% felt there was a problem, 29% responses were negative and 14 had no opinion. Most respondents cited Chrysaora followed by Cyanea, Physalia, and Aurelia as troublesome jellyfishes, with Mnemiopsis as the most harassing ctenophore. All noted that the months July to November were the problem months.

Area 3 received 320 forms. Of the returns 53% responded positively to question 1, while 42% said no, and 4% had no opinion. Again Chrysaora followed by Cyanea, Physalia, Aurelia and Rhopilema was singled as the greatest menace to all concerned. Mnemiopsis was the problem ctenophore. Most respondents noted that greatest abundances seemed to occur during high tides when SW or NE winds prevailed. Ctenophores were likewise noted abundant during high tides and SW or NE winds. The period May to November was singled out as that when each individual seemed most affected, be it by jellyfish or ctenophore.

Area 4 received 155 forms and it is assumed that the negative returns indicate the public feels there was no real problem caused by "noxious coelenterates" in that area.

Area 5 received 90 forms. The responses were negative, indicating no problem.

Hospitals: Ten hospitals located in coastal counties were contacted. Most reported (Table 23) that they had never seen or had a patient who needed treatment for jellyfish stings. Of the five positive reports received in 1972, three were from Carteret General Hospital, one from J. Arthur Dosher Hospital, and one from New Hanover Hospital. Every case treated for Physalia stings following their onshore deposition by the northeasters of April 1972.

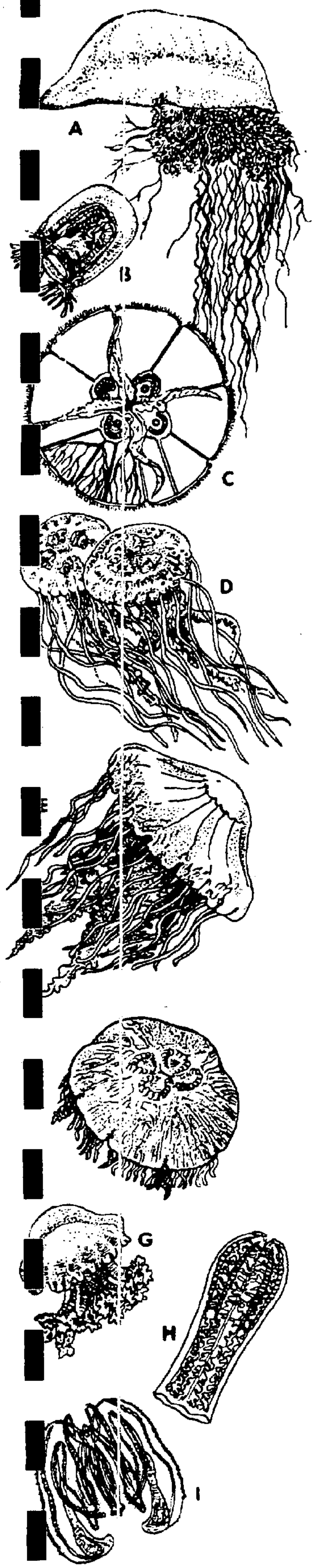
Doctors: Some 300 interview forms were sent out to physicians (Table 24). A positive response was reported by only nine doctors who simply washed the jellyfish sting and treated the area with Benadryl or Supercainol. Most serious encounters were with patients who had been stung by Physalia washed up on the beach. Treatment for Chrysaora stings was simple washing. Only one used meat tenderizer (Cargo and Schultz, 1971) which was a proven suppressant of the jellyfish stinging sensation and after effects.

Motels: A total of 236 motels were interviewed. There was a great reluctance by the owners to reply as they felt their comments might hurt their businesses. All who did reply noted emphatically that regardless of area along the coast there was a jellyfish problem from May to October, with the highest incidences of lost customer days in August and September (periods of highest Chrysaora incidences in Area 2).

Ferryboat and Bridge tenders: Ten key locations within Areas 2-5 produced few direct observations of coelenterates or ctenophores (Table 18) but all observers strongly agreed that when incidences of jellyfishes or ctenophores occurred the tourist beach traffic was down.

Sport shops, piers, etc.: Some 42 interviews were made of such places as surf shops, fishing piers, fishing boats, fish dealers, etc. All reluctantly agreed that on occassion there were abundances of jellyfishes that caused the public to shun their area of business.

Table 21. Typical fisherman inquiry form.



THE UNIVERSITY OF NORTH CAROLINA

INSTITUTE OF MARINE SCIENCES

MOREHEAD CITY, N. C. 28557
919: 726-6841

Dear Sir:

May I take a few minutes of your time to ask you to fill out the questionnaire below, it will help us in a survey of jellyfishes on the North Carolina coast. All information on this report will be HELD IN STRICTEST CONFIDENCE. Only in unusual circumstances, such as an unusually severe case, will we seek out additional information.

Date ______________ Address(city) ____________________________

1. I believe there is ___ is not ___ a local problem with jellyfish.
   I notice the purple or pinkish-blue (see drawing A on left) with oblong air-sac and tentacles from ____ to ____.
   I notice the pancake-shaped, 2 ft. wide with no or short tentacles jellyfish (drawing C&F), from ____ to ____.
   I notice the dome-shaped jellyfish (drawing D) with long tentacles present from ____ to ____.
   I notice the egg-shaped clear with blue lines (drawing I), no tentacles, sea walnut, jelly, or gall from ____ to ____.
   I notice the large egg-shaped with pink lines (drawing H), no tentacles, sea walnut, jelly, or gall, from ____ to ____.
   I notice the orange with purple tentacles, winter jellyfish (drawing E), from ____ to ____.
   I also notice type _______ (see drawing) jellyfish during the months of ____________________.
2. When the jellyfish with tentacles (no air sac) is present the sea walnuts are ___ are not ___ so abundant.
3. I note that jellyfish are more common on ____ tide stage.
   I note that sea walnuts are more common on ____ tide stage.
4. Do you associate abundance of jellyfish ____ or sea walnuts with winds? If so, which winds yield most? ____ least? ____.
5. Jellyfish ____ or sea walnuts ____ are more common near inlets?
6. The incidence of jellyfish affects my ____ business during the months of ____.
   The incidence of sea walnuts affects my business during the months of ____.
7. I try to operate by taking the following action against them.
   ____.
8. Concentrations of ___ jellyfish or ____ sea walnuts ____ (rarely, commonly, always) prevent the operation of my skiff, boat, trawler, and/or swimming.
9. When stung by a jellyfish, I treat the itch or rash by ________
   ____
10. I (would, would not) use the area more for _____ if the jellyfish or sea walnuts were not present.
11. Do heavy rains have an effect on the presence of jellyfish? ______
    How? ____
    Do heavy rains have an effect on the presence of sea walnuts? _____
    How? ____
12. I am located _____ (# of miles) from ___________ (what body of water).

Table 22. General features of expected coelenterates and ctenophores.

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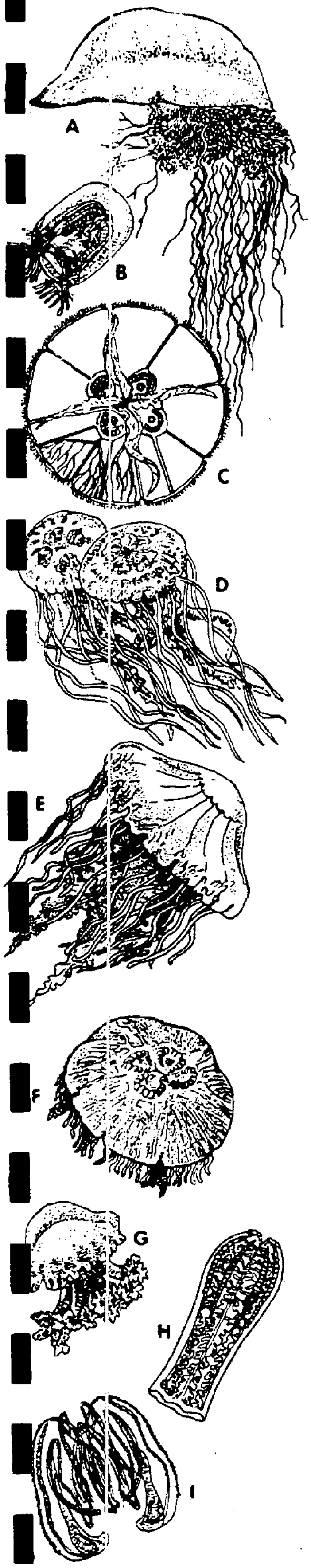

GENERAL FEATURES REGARDING

JELLYFISH AND SEA WALNUTS

A. Portuguese Man-O-War. Occurrence: Summer, oceanic. Color: Bluish-pink with large air sac; tentacles numerous. Size: Tentacles to 20 ft; air sac 18 inches.

B. *Nemopsis bachei*. Occurrence: November to March; brackish water. Color: Clear with white internal structures. Size: Less than 1 inch; tentacles very short.

C. & F. Moon Jellyfish. Occurrence: April to November; oceanic or in sounds. Color: Pink-white with four white or pink horseshoe shaped internal structures. Size: Flat plate up to 2 ft across. Tentacles short, hardly visible.

D. Summer Jellyfish, Sea Nuttle. Occurrence: April to November in sounds or near inlets. Color: Two color phases, dome white or with red streaks. Size: Dome 8 inches; tentacles to 12 ft.

E. Winter Jellyfish. Occurrence: October to March in sounds or open oceans. Color: Dome orangish; tentacles purplish-red. Size: Dome 8 inches in sounds, 3 ft in open oceans. Tentacles to 4 ft.

G. *Rhopilema verrillii*. Occurrence: Late summer; sounds or oceanic. Color: Dome yellowish; heavy parts whitish. Size: Dome 12 inches; arms 7 inches.

H. Winter Sea Walnut. Occurrence: Sounds or near inlets. Color: Clear body with pink bands; no tentacles. Size: Four inches wide, 6-8 inches long; mitten shaped.

I. Summer Sea Walnut. Occurrence: All year; everywhere. Color: Clear with 8 little bands which irridesce. Size: Less than about 4 inches.

Economic Investigations of Noxious Coelenterates in Coastal North Carolina being conducted by the U.N.C. Institute of Marine Sciences, Morehead City, N.C.

Table 23. Hospital Incidence Report

This questionnaire is an attempt to determine the economic importance of jellyfish incidence along North Carolina's coastal areas. This is associated with a study recently begun to determine distribution, species composition, relative and seasonal abundance of jellyfish in North Carolina and to determine the economic impact of these animals to coastal North Carolina's commercial fishing, marine sports fishing, and tourist industries.

All information on this report will be STRICTLY HELD IN CONFIDENCE* Only in unusual circumstances, such as an unusually severe case, will we seek out the patient for information regarding the effect of jellyfish.

____
Date

1. What part of body is affected?____________________

2. Location of incident.____________________

3. Description of organism____________________

4a. Relative abundance of jellyfish in that area. (many-few)____________

4b. Were all of the jellyfish like the one described above?____________

5. Is this the first time you have been stung by a jellyfish?_____If not, - explain.(when-where).____________________

6. Will this incident affect your returning to the area for recreation?____

7. What was your activity associated with the incident?____________

Do Not Write below this line

To be filled out by attending physician

E.R.#________________

1. ____________________
Name of Physician

____
Address

2. Severity of Case____________________

3. How long before treatment was begun did the incident occur?__________

4. Treatment____________________

5. What First-Aid measures, if any, were applied?________________
____

6a. Does Patient require extended care?____ Describe________________

6b. How long will he require treatment (in your opinion)?________________

Comments____________________________

Table 24. Medical Doctor form.

Economic Investigations of Noxious Coelenterates in
Coastal North Carolina being conducted by the U.N.C.
Institute of Marine Sciences, Morehead City, N.C.

This questionnaire is an attempt to determine the economic importance of jellyfish incidence along North Carolina's coastal areas. This is associated with a study recently begun to determine distribution, species composition, relative and seasonal abundance of jellyfish in North Carolina and to determine the economic impact of these animals to coastal North Carolina's commercial fishing, marine sports fishing, and tourist industries.

All information on this report will be <u>HELD IN STRICTEST CONFIDENCE</u>. Only in unusual circumstances, such as an unusually severe case, will we seek out the patient for information regarding the effect of jellyfish.

Date ______________________ Address (city) ______________________

1. I tend to have ______ cases a year, mostly during the months of ______
____

2. The patients most often describe the jellyfish as ______________________

3. Treatment ____

4. The cases I receive could be generally described as ______________________
____

5. In what area are most of your patients stung (what body of water?)
____

6. What First-Aid treatment do you recommend? ______________________
____

7. How long before treatment was begun did the incident(s) occur? __________
____

8. Is there one particular case which was unusually severe? ______________
Describe: ____

9. What type of people are most often affected by jellyfish in your area (tourists, commercial fishermen, sports fishermen)? ______________________
____

10. What activities are most commonly associated with jellyfish stings? ______
____

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Dr. T. Linton and Mr. E. McCoy were most instrumental in handling aspects of the subcontract at the state-federal level while Dr. G. Holcomb and Mr. W. Fulk handled the contract on the University level.

Recommendations

As a result of this study and survey we recommend the following action for further research and study:

1) efforts be made to learn more concerning the biology of the ctenophore Mnemiopsis leidyi. Methods of its control would remove one obstacle from the public as well as a food source for the jellyfish Chrysaora quinquecirrha.

2) efforts should be made to find some way to control the summer jellyfish C. quinquecirrha by way of attacking the cyst and polyp stages of its life cycle.

3) the state should carefully weigh whether it is more advantageous to create and enlarge oyster reefs, which are key components to jellyfish polyp and cyst stages of its life cycle for survival and attachment, or to alter present oyster culture practices.

4) the state should weigh carefully the long-range effects of jellyfish and ctenophore eradication for it is believed the feeding habits of jellyfishes and ctenophores deprive the water column of a vast quantity of zoo- and phytoplankters-food for fishes and many other aspects of the food web-chain.

5) the state should weigh the side effects of too much damming which could permit more saline water intrusion into the great sounds and estuaries and the repercussions thereof to coelenterates and ctenophores and the associated food web-chain.

6) the state should develop an alert system which would notify the public of areas, seasons, etc., of dense concentrations or probabilities of encountering coelenterates and ctenophores.

7) the state should review the entire Pamlico Sound complex to note man's alterations as they directly or indirectly affect the coelenterate-ctenophore problem.

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